GENERAL DESCRIPTION

See Figure 1.

The ZF-Ecomat transmission consists of a hydrodynamic torque converter, with a lock-up clutch for direct drive, a hydrodynamic retarder and a rear-mounted multiple-speed planetary transmission.

The torque converter provides smooth starting without mechanical wear, and compensates automatically for various load conditions by providing the necessary output torque.

The various ratios in the planetary transmission are shifted automatically with no interruption in traction. Gearshifts are performed in response to signals from the electronic control unit (EST 147). In response to different variables in the vehicle and transmission, the EST 147 sends signals to the hydraulic solenoid valves that actuate the corresponding clutches and brakes.

A lock-up clutch in the torque converter provides a direct mechanical link between engine and planetary transmission after the vehicle start-up phase, thus eliminating the power losses encountered in conventional automatic transmissions where the torque converter remains in operation all the time.

The hydrodynamic retarder is located between the torque converter and the planetary transmission module. This means that braking force is dependent on the gear engaged. Therefore, the braking effect is excellent even at low speeds. Braking torque can either be infinitely variable or subdivided into individual retardation steps.

The vehicle can be slowed when driving downhill, in town traffic or at bus stops by using the retarder, which does not rely on friction and is therefore not subject to normal wear.

Figure 1 - ZF Transmission
HYDRODYNAMIC RETARDER

The primary function of the retarder is to provide an additional braking force for the vehicle by using the hydraulic power generated by the transmission. Brake component wear can be reduced by the use of the retarder.

The retarder integrated in the transmission is a single-flow, hydrodynamic, continuous-brake located between the torque converter and planetary gear section.

During braking, a foot-operated control switch sends a signal to the control module through the EST via the J1939. The signal is then sent to the accumulator solenoid to supply extra oil in the retarder module and the retarder control valve. The retarder control valve is signaled to open, allowing oil to flow freely in the retarder circuit. The rotor is driven by the vehicle through its axle, propshaft, transmission and clutch and its rotation causes the retarder oil to undergo centrifugal acceleration, making the oil circulate in the retarder.

The rotor forces the fluid into blades in the non-rotating stator. The direction of oil flow is reversed and slowed. Due to the reverse of oil flow direction in the stator, the rotation of the rotor is also slowed, as is the vehicle speed.

The braking effect of the oil flow is converted into heat. The hot oil is cooled in the transmission oil cooler. The heat transferred to the coolant is then cooled by the radiator. The cold oil is returned to the transmission and stored in the base plate cavity.

RETARDER CONTROLS

The retarder controls consist of a switch on the throttle pedal, and three switches on the brake pedal.

A standard two-position toggle switch is used to control the retarder. Throttle release triggers the retarder to contribute 50% of its total efficiency. A 100% retarder efficiency is achieved when the brake pedal is applied until it reaches the first microswitch, or the equivalent of 28° pedal travel.

Since operating the retarder raises the transmission oil temperature, it is possible the permissible oil temperature will be exceeded. The TRANSMISSION PROBLEM tell-tale lamp on the instrument panel will illuminate whenever an over-temperature condition exists.

TORQUE CONVERTER

The hydrodynamic torque converter, which uses the Tri-Lok operating principle, is mounted on the input end of the planetary gear train. It consists of the impeller, turbine, stator and the oil needed for torque transmission. The converter operates only when the vehicle is starting and is then automatically locked up.

INTEGRATED TORSION DAMPER (OPTIONAL)

On T-Drive vehicles (40 ft and articulated), a torsion damper is integrated in the torque converter to help reduce vibration in the drive train. The torsion damper also increases initial torque capacity and allows the engaging of gears at a lower engine speed.

PERIPHERALS

See Figure 2.

SPEED RANGE SELECTION SYSTEM

The speed range selector is a three push button selector: D (DRIVE) - N (NEUTRAL) - R (REVERSE). When any D or R button is pushed, the button lights up to indicate the transmission is ready to operate in the selected range. See the OPERATORS MANUAL for driving instructions.

GEAR CHANGE

Gears are changed automatically depending on vehicle speed, engine RPM and engine load. Engine load is determined by the position of the accelerator pedal.

The signal is transmitted to the EST 147 which, depending on its programming, will adjust the shift quality accordingly. It is then converted through the clutch application into a pressure signal on the basis of a characteristic curve that is matched to the engine.

The pressure modulation device in the transmission ensures that the clutch engagement pressure is matched to the engine load.

EST 147 ELECTRONIC CONTROL UNIT

The electronic control unit controls and monitors the function of the transmission. The electronic control unit receives various data from the vehicle, the engine and transmission, and processes these into signals used for controlling the transmission.

Depending on the option, the EST may also be programmed to automatically switch the transmission to neutral if a pressure switch in the brake pneumatic line detects that the pedal brake pressure is high enough to determine that the bus is likely coming to a standstill. This feature is called NBS, or Neutral Bus at Stop.

The electronic control unit is capable of self-diagnosis (see the ZF REPAIR MANUAL for the TESTMAN PRO diagnostic device). Sporadic and continuous faults are stored in a permanent memory and may be called up any time using the diagnostic device. A TESTMAN PRO diagnosis connector is located in the operator's upper left compartment.
WELDING PRECAUTION:
All multiplex control modules and electronic components must be disconnected before beginning any welding on the vehicle's structure.

TOWING

WARNING:
Before attempting any towing, refer to towing instructions in section 18: HOISTING AND TOWING in this manual in order to prevent damage to the transmission. Do not attempt to start the engine by pushing or towing the vehicle.

NOTE:
To avoid incorrect readings, plug in the ZF DIAGNOSTIC READER before turning on the ignition and starting the engine.
MAINTENANCE

Good maintenance means safe operation of the transmission. Therefore, it is important to carry out all required maintenance correctly.

**CAUTION:**
For maintenance purposes, always check the oil level with the transmission at operating temperature.

**CAUTION:**
Proper maintenance must include cleaning and inspection of the exterior of the transmission on regular intervals. Prevent the accumulation of grime and mud that could accelerate corrosion and therefore damage the transmission. The severity of service and operating conditions will determine the frequency of these inspections, but the minimum requirement is to check at each oil change.

**NOTE:**
Proper maintenance must include cleaning and inspection of the exterior of the transmission on regular intervals. Prevent the accumulation of grime and mud that could accelerate corrosion and therefore damage the transmission. The severity of service and operating conditions will determine the frequency of these inspections, but the minimum requirement is to check at each oil change.

**NOTE:**
Refer to the ZF REPAIR MANUAL for detailed maintenance, troubleshooting and diagnosis procedures. Also see the TROUBLESHOOTING GUIDE at the end of this section.

COLD CHECK

**CAUTION:**
This procedure serves a specific purposes and should not be used as a regular verification method. Only use when specified in this manual.

1. Park the vehicle on a level surface and apply the parking brake.
2. Place the transmission in NEUTRAL (N) and let the engine idle (maximum 750 rpm).
3. Check the oil level. The oil level must be between the upper and lower level marks for the stationary range. Adjust if necessary.

**NOTE:**
The dipstick may not have the STOP or STATIONARY mark.

4. After 3 to 5 minutes of idling, the oil temperature should have reached 86°F (30°C). Check the oil level. The oil level must be between the upper and lower level marks for the stationary range. Adjust if necessary.
5. Perform a hot check of the transmission oil level.

HOT CHECK

See Figure 4.

1. Operate the vehicle in drive (D) to allow the oil temperature to rise.
2. Park the vehicle on a level surface and apply the parking brake.
3. Place the transmission in NEUTRAL (N) and let the engine idle (maximum 750 rpm).
4. After 2 minutes of idling, the oil temperature should have reached 180°F to 195°F (80°C to 90°C). This is the correct operating temperature at which to check and is indicated on the vehicle’s gauge.
5. Check the oil level. The oil level must be between the upper and lower marks of the hot range. If the oil level is not between these marks, repeat the check, ensuring that the cap of the dipstick is closed tightly when the dipstick is inserted.
6. Adjust the oil level if necessary.
ADDING OIL

Transmission oil is poured through the same hole as is used by the dipstick. One quart (1 liter) changes the level by approximately 0.4 inch (10 mm).

OIL AND FILTER CHANGE

The transmission oil and filter must be changed at intervals determined by operating conditions and the type of oil used. Oil change should be in line with engine oil change intervals, but at least once a year. For a typical timetable, see section 19-4: FLUIDS AND LUBRICANTS for more information.

OIL CHANGE (AT OPERATING TEMPERATURE)

See Figure 5.

1. Switch off the engine.
2. Drain oil through the drain hole in the oil pan. See the DRAINING OF THE TRANSMISSION OIL subsection in this section.
3. Unscrew the filter cover and remove the filter.
4. Check filter for contamination.

☞ CAUTION:
Collect the used oil in a container large enough for the purpose, and dispose of the oil and filter. Some local authorities impose strict regulations regarding the disposal of used oil and oil related products to protect the environment. Contact your local authority to determine the proper method of disposal.
5. Insert new filter.

**CAUTION:**
At every oil change, the oil filter must be replaced. It must not be cleaned and reused.

6. Screw in the drain plug with a new copper seal washer. See the **TECHNICAL DATA AND SPECIFICATIONS**, at the end of this section for torque values.
7. Check the filter o-ring and ensure it is still correctly seated and undamaged.
8. Replace the o-ring in the filter cover; smear the o-ring with transmission oil.
9. Replace the filter cover and tighten the hex bolts. See the **TECHNICAL DATA AND SPECIFICATIONS**, at the end of this section for the torque values.
10. Pull out the dipstick and pour in a maximum of 2.6 gal. US (10 liters) transmission oil.
11. Start the engine and immediately, with the engine idling, slowly add transmission oil to top-up the system until it is within the **COLD** range. This will ensure that there is sufficient oil to allow the transmission to be brought to operating temperature, at which point the oil level can be correctly adjusted.
12. Insert the dipstick and check the oil level as directed in the paragraph entitled, **COLD CHECK**. Adjust the oil level if necessary.
13. Run the vehicle until the transmission oil reaches operating temperature 180 to 195°F (80 to 90°C). Check the oil level at operating temperature (**HOT CHECK**) and adjust if necessary.

**DRAINING OF THE TRANSMISSION OIL**

For a more efficient draining, warm up the transmission until it reaches its normal operating temperature. Remove the drain plug and let the fluid drain out overnight.

**TRANSMISSION REPLACEMENT**

**GENERAL**

The transmission must be removed when the replacement of internal parts is required.

The basic assembly is removed as one unit. Inspect visually before removal. Look for obvious leaks and unserviceable parts.

**CLEANLINESS**

Thoroughly clean out all tools and the work location surroundings. Cleanliness is of the utmost importance for any work done on a transmission and cannot be emphasized too much.

**WARNING:**
Lubricants and cleaning agents must **NOT** be allowed to get into the environment, **NOR** the sewage system. All local environment regulations must be respected for safety and legal reasons. Dispose of used oil, dirty filters, lubricants and cleaning agents in accordance with environmental protection, as well as local government guidelines.

Collect oil in a suitably large container.
When working with lubricants and cleaning agents always refer to the manufacturer's instructions.

**TRANSMISSION REMOVAL**

**CAUTION:**
Cut off main power to avoid inadvertent engine starting. See section 09-1: **STARTING SYSTEM** in this manual for further information.

**NOTE:**
Tag and identify each line connection before disconnecting, to make reassembly easier. Move lines out of the way to prevent damage. Cover or plug all open line ends to prevent contamination.

1. Raise the vehicle.

**CAUTION:**
**VEHICLE HOISTING.** Follow your internal safety procedures. Use appropriate safety equipment for your protection. See section 18: **HOISTING AND TOWING** for more information.

**CAUTION:**
A repair pit or an adequate lifting device are essential to provide sufficient working space for the various steps of transmission removal. Firmly anchor the vehicle body. When adjusting the dolly to partly support the weight of the transmission, take care not to lift up the body inadvertently, thus bleeding off the lifting height adjustment valves and transferring the whole vehicle weight on the dolly.
2. Remove the dust-guard from under the transmission.
3. Use steam (or an appropriate solvent) to clean the outside of the transmission case and adjacent surfaces.
4. Disassemble the drive shaft. See section 10-5: DRIVE SHAFT for the disassembly procedure.
5. Drain the transmission fluid. See the DRAINING OF THE TRANSMISSION OIL subsection in this section. Drain the coolant from the transmission fluid cooler. Also, drain the engine cooling system as described in section 09-3: ENGINE COOLING.
6. Remove the accumulator air hoses.
7. Unplug the electrical harness connectors and remove the harness.
8. Disconnect the retarder controls.
9. Disconnect the control cables and position them out of the way so that they will not interfere when the transmission is being lowered.
10. Disconnect the oil cooler's coolant lines.
11. Loosen the torque converter back-plate.
12. Loosen the transmission mounting bolts. The upper bolts must be loosened through the engine compartment access door.

**CAUTION:**
Do not drain any fluid directly on the ground. Recapture all fluids in appropriate containers.

13. Remove bolts and flat washers at the transmission ten attachment points. See Figure 6. Remove the upper bolts first in order to have an easier access when removing the last bolt.
14. After the transmission has been freed lower the dolly, making sure that nothing interferes with the removal operation.
15. Check the transmission as indicated in the TRANSMISSION VERIFICATION subsection.

**TRANSMISSION VERIFICATION**

**CHECKING THE FLEXPLATE**

Whenever the transmission is removed from the vehicle, remove the flexplate from the engine. Check each of the plates for cracks or damage.

**CHECKING FLYWHEEL HOUSING**

Check the transmission mounting surface on the engine flywheel housing for burrs or raised metal. Remove any defects to ensure the transmission, when installed, will seat solidly and squarely.

**TRANSMISSION INSTALLATION**

To install the transmission, follow the REMOVAL procedure, but in the reverse order.

**CAUTION:**
The transmission must be moved forward by at least 4 in (102 mm), before it can be lowered. Turn the transmission toward the left-hand side of the vehicle in order to clear the undercarriage structure.

**CAUTION:**
- Tighten all bolts to the specified torque. See Figure 7 for appropriate torque values.
- Only use hardened, flat washers with the bolts. Never use toothed lock washers or similar.
- See the ELECTRICAL CONNECTIONS heading in section 16: 24-VOLT ELECTRICAL SYSTEM for the torque value of the transmission harness connector.
**TECHNICAL DATA AND SPECIFICATIONS**

**ZF HP552/554 TRANSMISSION**

**PERFORMANCE**
- Maximum input speed: 2800 rpm
- Maximum net input torque: 922 lb-ft (1250 N•m)
- Maximum net input power: 240 kW
- Retarder maximum torque: 959 lb-ft (1300 N•m)

**OIL CAPACITY**
- Initial filling of dry transmission: 8 gal. US (30 ℓ)
- After installing new transmission: 5.25 gal. US (20 ℓ)
- At oil change: 4 gal. US (15 ℓ)

*Note: these are approximate quantities, use the dipstick for the exact amount.*

**LUBRICATING SYSTEM**
See the ZF TE-ML 14 lubricant List and section 19-4: **FLUIDS AND LUBRICANTS** of this manual for approved oil specifications.

**OIL CHANGE**
For recommended transmission oil change intervals, see section 19-4: **FLUIDS AND LUBRICANTS** of this manual.

**TORQUE**
- Bolts: filter cover: 17 lb-ft (23 N•m)
- Drain plug: 37 lb-ft (50 N•m)

**Figure 7 - Engine and Transmission Assembly**
ZF 604 TRANSMISSION

PERFORMANCE
Maximum input speed ........................................ 2800 rpm
Maximum net input torque .................. 1271 lb-ft (1750 N•m)
Maximum net input power ......................... 240 kW
Retarder maximum torque ..................... 1106 lb-ft (1500 N•m)

OIL CAPACITY
Initial filling of dry transmission .............. 8 gal. US (30 ℓ)
After installing new transmission .......... 5.25 gal. US (20 ℓ)
At oil change ............................................ 4 gal. US (15 ℓ)

NOTE: these are approximate quantities, use the dipstick for the exact amount.

LUBRICATING SYSTEM
See the ZF TE-ML 14 lubricant List and section 19-4: FLUIDS AND LUBRICANTS of this manual for approved oil specifications.

OIL CHANGE
For recommended transmission oil change intervals, see section 19-4: FLUIDS AND LUBRICANTS of this manual.

TORQUE
Bolts: filter cover .................................... 17 lb-ft (23 N•m)
Drain plug ................................................. 37 lb-ft (50 N•m)
## TROUBLESHOOTING GUIDE

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<th>PROBLEM</th>
<th>POSSIBLE CAUSE</th>
<th>REMEDY</th>
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<tr>
<td>Engine will not start.</td>
<td>a. Speed range selector not in neutral.</td>
<td>a. Select neutral.</td>
</tr>
<tr>
<td></td>
<td>b. Electronic control unit plug not attached.</td>
<td>b. Connect plug.</td>
</tr>
<tr>
<td>No gear engages in transmission.</td>
<td>a. Engine idling speed &gt; 900 rpm.</td>
<td>a. Adjust the engine idling speed.</td>
</tr>
<tr>
<td></td>
<td>b. Only for transmission with EXTERNAL GEAR INTERLOCK function—Service brakes</td>
<td>b. Apply service brakes.</td>
</tr>
<tr>
<td></td>
<td>not applied.</td>
<td>c. Switch ignition off/on.</td>
</tr>
<tr>
<td></td>
<td>c. Electronic control unit in failure mode.</td>
<td></td>
</tr>
<tr>
<td>Vehicle does not move.</td>
<td>a. Oil level too low.</td>
<td>a. Check/correct oil level.</td>
</tr>
<tr>
<td>Oil temperature too high.</td>
<td>a. Oil level too high.</td>
<td>a. Check/correct oil level.</td>
</tr>
<tr>
<td></td>
<td>b. Retarder engaged.</td>
<td>b. Disengage the retarder activation.</td>
</tr>
<tr>
<td></td>
<td>c. Internal fault.</td>
<td>c. Request Service</td>
</tr>
<tr>
<td>Retarder does not work.</td>
<td>a. Oil level too low.</td>
<td>a. Check/correct oil level.</td>
</tr>
<tr>
<td></td>
<td>b. Retarder solenoid valve not working.</td>
<td>b. Check solenoid valve/electrical connections.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If necessary, ask for Service.</td>
</tr>
</tbody>
</table>

*Table 1 - Troubleshooting Guide*