Operating Instructions

ZF-Ecomat
HP 500  HP 590  HP 600
ZF-Ecomat 2 / ZF-Ecomat 2 plus
HP 502  HP 592  HP 602
HP 502C  HP 592C  HP 602C
for city and intercity buses and coaches

4139 758 103
Before the vehicle first enters service, please note the following points:

- Read the Operating Instructions carefully and follow the safety instructions.

- To ensure that the transmission achieves the required level of operational safety and reliability, always pay careful attention to the maintenance instructions.

The ZF After-Sales Service specialists are available to assist you in carrying out maintenance work at the transmission or to help if any other problems arise. Their addresses are listed in the "ZF Company Directory" (order number 0000 762 703) or on the Internet under www.zf.com/servicenetz.

NOTE
All details in these Operating Instructions refer to the basic version of the ZF-Ecomat transmission. Due to the large number of installation options, no precise information can be provided for any specific vehicle. If there are any differences in operation between the instructions in this brochure and the Operating Instructions specific to an individual vehicle manufacturer, the vehicle-specific instructions are the ones to follow.

Motoring pleasure with the ZF-Ecomat is brought to you by

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The following safety instructions appear in this manual:

NOTE
Refers to special processes, methods, information, etc.

CAUTION
This is used when incorrect, unprofessional working practices could damage the product.

⚠️ DANGER !
This is used when lack of care could lead to personal injury or material damage.

⚠️ THREATS TO THE ENVIRONMENT !
Lubricants and cleaning agents must not be allowed to enter the soil, ground water, or sewage system.
- Ask your local environment agency for safety information on the relevant products and adhere to their requirements.
- Collect used oil in a suitably large container.
- Dispose of used oil, dirty filters, lubricants, and cleaning agents in accordance with environmental protection guidelines.
- When working with lubricants and cleaning agents always refer to the manufacturer's instructions.

NOTE on cleaning the vehicle / transmission

CAUTION
When cleaning, always ensure that the steam cleaner or high-pressure cleaner does not make direct contact with the screw cap of the dipstick. Any water ingress through the breather can damage the transmission!
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1 Description

The Ecomat range of transmissions comprises a hydrodynamic torque converter (Föttinger t/c) with lock-up clutch, a hydrodynamic retarder, and a downstream, multi-ratio planetary transmission.

The torque converter is a starting unit which operates without mechanical wear and which adapts its setting across an infinitely variable range to suit prevailing conditions (delivering the required level of input torque).

The gears in the planetary transmission are engaged automatically without any interruption in traction. The signals for gear changes are supplied by an ECU (electronic shift control unit). Depending on various parameters obtained from vehicle and transmission, this ECU engages the appropriate multi-disc clutches and brakes via the electro-hydraulic transmission control unit.

A lock-up clutch installed in the torque converter establishes a direct mechanical connection between engine and planetary transmission after the starting phase. This lock-up process eliminates the power losses traditionally associated with torque converter transmission.

The hydrodynamic retarder is installed between the torque converter and the planetary transmission. This means that the level of retarder braking force on the output shaft is gear-dependent. As a consequence, full braking action is available, even at the lower end of the speed range. The braking torque can be controlled across an infinitely variable range or can be sub-divided into several steps.

Braking action while driving downhill or in city traffic can be delivered by the retarder without mechanical wear, thereby extending the life of the service brakes.

ZF offers a range of powerful PTOs for the entire range of Ecomat applications. These PTOs are engine-dependent and, depending on their version are either permanently driven or disengagable.
1.1 Structure of Basic ZF-Ecomat Transmission

Key to drawing
1  Input
2  Torque converter lock-up clutch
3  Torque converter
4  Hydrodynamic retarder
5  Rotating multi-disc clutches
6  Fixed-position multi-disc brakes
7  Output
8  Oil cooler
NOTE
This system diagram illustrates one of the possible system solutions for the ZF-Ecomat with the ECU 18 electronic shift control unit and all related components.

**Key to drawing**
1. Vehicle circuit interface
2. Temperature display unit
3. Speed range selector (digital speed range selector)
4. Type plate
5. ECU 18 electronic shift control unit
6. Plug connection for MOBDIG 2000 / ZF-TestmanPro
7. From air supply for auxiliary consumers
8. coolant connections
9. Solenoid valve for retarder accumulator
10. Retarder accumulator
11. Solenoid valve for retarder activation
12. Temperature sensor
13. Pressure relief valve (1.2 bar)
14. Solenoid valve for retarder torque reduction
15. Pressure switch (retarder input signal for ECU 18)
16. Footplate brake valve with modulator valve for activating the service brake
17. Retarder hand lever
18. Kickdown switch
19. Accelerator pedal
20. Linkage for fuel injection pump
21. Load sensor for recording engine load status
22. Compressed air line for retarder activation (optional 15 and/or 16), Pressure line for modulated pressure (0 to 3 bar)
23. Changeover valve
24. Brake pedal for service brake activation
1.2 System Solution for the ZF-Ecomat

HP 500, HP 590, HP 600 range with ECU 18 for city & intercity buses and coaches.

The electrical wiring from the Ecomat system to the ECU shift control unit is routed via the vehicle circuit interface (1).

The ECU18 (5) electronic automatic shift system is used to control and monitor transmission operation. The ECU records input parameters from vehicle and transmission (speed range, engine load, speeds etc.) and converts them into signals to activate the hydraulic transmission unit.

The driver can intervene directly in the Ecomat control unit using the

- speed range selector (pushbutton switch) (3)
- kickdown (18)
- accelerator pedal (19)
- brake pedal (24)
- retarder activation switch (16)

- The speed range selector (3) can be used to pre-select the speed range. The pushbutton activated then lights up (continuous light).
- Using the kickdown switch (18), the shift points can be relocated to a higher speed range which means that the transmission remains in each gear for more extended periods or that downshifts occur sooner.
- To activate the retarder, refer to vehicle Operating Instructions.
- Temperature sensors are installed to monitor the oil temperature. The temperature is displayed by means of an analog display (2) or warning lamp. Whenever defined temperature limits are exceeded, retarder torque is reduced continuously.
- Engine load information is transmitted from the electronic engine control unit to the ECU18 (5).
NOTE
The system diagram illustrates one of the possible system solutions for the Ecomat 2 / Ecomat 2 plus with ECU 46 C/ECU 47 C and/or ECU 146/ECU 147 respectively with all required components.

Key to drawing

1 Vehicle circuit
2 Speed range selector (digital speed range selector with option of CAN speed range selector)
3 Type plate
4 ECU (electronic shift control unit) ECU46C/ECU47C and/or ECU146/ECU147
5 Plug connection MoBiDIG 200/TestmanPro
6 Coolant connections
7 Solenoid valve for retarder accumulator
8 Proportional solenoid valve for retarder activation
9 Temperature sensor
10 Retarder accumulator
11 Footplate brake valve for activation of service brake and infinitely variable retarder activation via CAN
12 Retarder hand lever, electrical
13 Kick-down switch
14 Accelerator pedal
15 Linkage to fuel injection pump
16 Load sensor (ZF-Ecomat-2 application without CAN)
17 Retarder switch ON/OFF
18 Pressure switch for NBS (Bus Stop Neutral)
19 Impulse sensor, speedometer
1.3 System Solution for ZF-Ecomat 2/ZF-Ecomat 2 plus

HP 502, HP 592, HP 602 range and/or ECU 502 C and HP 592 C, HP 602 C with ECU 46C / ECU 47C and ECU 146 / ECU 147 respectively, for city & intercity buses and coaches (C=CAN-capable)

The electrical wiring from the Ecomat system is routed to the ECU and to the CAN bus in the vehicle via the vehicle circuit interface (1).

The (electronic automatic shift system) ECU helps to control and monitor operation of the transmission. The ECU records input parameters from vehicle and transmission (speed range, engine load, speeds etc.) and processes these into signals to activate the hydraulic transmission control unit.

The driver can intervene directly in the Ecomat control unit using the

• speed range selector (pushbutton switch) (3)
• kickdown (pushbutton switch) (17)
• accelerator pedal (19)
• brake pedal (24)
• retarder activation switch (16)

• The speed range selector (3) can be used to pre-select the speed range. The pushbutton activated then lights up (continuous light).

• Using the kickdown switch (17) the shift points can be relocated to a higher speed range, i.e. the transmission then spends longer in each ratio before upshifts and that downshifts occur sooner.

• Activation of the retarder: Refer to vehicle Operating Instructions.

• Temperature sensors are installed to monitor the oil temperature. This information is transmitted via CAN bus, digital output on the ECU or via direct wiring and is displayed by means of a display panel, analog display or warning lamp. Whenever defined temperature limits are exceeded, retarder torque is reduced continuously.

• Engine load information is transmitted from the electronic engine control unit to the ECU by means of CAN or load sensor (20) or PWM signal.
In conjunction with a proportional solenoid in the electro-hydraulic control unit, pressures for activating the clutch elements are modulated in accordance with engine load.

• Special feature of the Ecomat 2 plus:
This range of transmissions has been designed to contend with higher temperatures by means of a choice of modified sub-assemblies built with adapted materials, refer to Chapter 2.9.
1.4 Auxiliary Transmission

Depending on vehicle version and application, the ZF-Ecomat transmission can be equipped with an 80° angle drive or with an ST 10000 angle drive.

Key to drawing:
1 Basic transmission
2 Coaxial output
3 80° angle drive without LHD axial offset or 80° angle drive with RHD axial offset RHD
4 ST 10000 angle drive
2 Operation

2.1 Digital and/or CAN speed Range Selector

Example

The vehicle is either equipped with a digital or a CAN speed range selector switch.

NOTE
Distinguishing features between CAN and digital speed range selector switches:

- Convex keys
- Neutral button does not lock
- ZF-Logo located laterally on Neutral button

2.1.1 Digital Speed Range Selector

3, 5, or 6 pushbuttons installed horizontally or vertically

R = Reverse
N = Neutral
D = Automatic forward driving range (Drive)
1, 2, 3 = limited forwards driving ranges

NOTE

- The respective button pushed will then lights up (continuous light).
- The respective button pushed flashes if it is not accepted by the transmission control unit.
2.1.2 CAN Speed Range Selector

2.1.2.1 Lighting of the CAN Speed Range Selector

**Button lighting colors:**
- Neutral button: Amber
- 1,2,3, D and R: Yellow

All buttons **light up for approx. 1.2 s:**
- Lighting test at system startup

All buttons **flash:**
- Serious internal fault in pushbutton
- Malfunction in CAN communication. Once this defect has been remedied, the lamp stops flashing.

All lamps **light up dimly:**
- Search lighting: To make it easier to find the buttons in the dark.

Individual buttons **light up brightly:**
- Function lighting: Identifies the active, pressed pushbutton.

**Exceptions:**
- If the transmission control unit is not providing the information required for lighting purposes, the lamps only light up in search mode. Nevertheless, the vehicle can still be driven in this status.
- The lighting is also deactivated if the pushbutton position can no longer be correctly established as a result of a hardware defect and the buttons only light up with search lighting.

**NOTE**
The lighting levels for search and function lighting can, if required, be set independently of one another. These levels are corrected in accordance with battery voltage.

2.1.2.2 Pushbutton Settings

**NOTE**
If several buttons are selected at the same time, the smallest gear inhibit button selected is chosen.

E.g.: If buttons 1, 2, 3 and D are selected at the same time, button 1 is activated.
2.2 Starting Engine

Engine can only be started if:
- Vehicle is stationary (brake applied)
- Speed range selector is in Neutral position ("N")

NOTE
Starter inhibit: If the speed range selector is not in Neutral position, the engine cannot be started.

CAUTION
Jump-starting only possible on battery, never on starting motor!
Do not switch ignition OFF / ON while vehicle is in motion!

2.3 Engaging Gear

Standard:
- Speed range selector in Neutral position
- Accelerator pedal at idle setting and \( n_{eng} < 900 \text{ rpm} \)
- Select desired speed range and/or direction of travel.

CAUTION
Never actuate speed range selector and throttle at the same time!

Transmission with additional "gear release" function
(additional installation by vehicle manufacturer, recommended by ZF)
- Speed range selector in Neutral position
- Accelerator pedal at idle setting and \( n_{eng} < 900 \text{ rpm} \)
- Select desired speed range and apply brake. System will only select the desired gear while the brake is being applied.

Operator errors when engaging gear
- Accelerator pedal actuated or \( n_{eng} > 900 \text{ rpm} \)
- If "gear release" is installed, but brake not applied
- Direction of travel "R" selected at a vehicle speed of > approx. 3 km/h
After selecting the desired speed range, the system does not engage a gear.

Transmission with auxiliary function "2nd Reverse gear button"
- To reverse the vehicle, press the R button on the speed range selector and also the R button on the dashboard.
2.4 Setting Off

After selecting the appropriate speed range, wait for approx. 1 to 2 seconds, release brake (if applied) and accelerate.

⚠️ DANGER !
On steep uphill gradients, always accelerate as soon as you release the brake! RISK OF ACCIDENT from vehicle rolling backwards!

⚠️ CAUTION
Do not set off immediately at temperatures below -15 °C. Instead, allow engine to warm up for approx. 5 minutes. Speed range selector in Neutral position.
2.5 Speed Ranges

Please refer to the vehicle’s Operating Instructions for precise information about the gears engaged in each of the speed ranges.

A defined range of gears / ratios is assigned to each speed range. Shifts are only executed at shift points defined by the electronic shift control unit.

Manual intervention in the automatic shift sequence (shifting right through the speed ranges) is not advisable.

⚠️ DANGER !
If the transmission is shifted into "N" while the vehicle is in motion, the power flow between engine and output is interrupted. This prevents the engine brake and retarder from being able to operate.
Risk of accident! - Apply brake!
For safety reasons, when faults occur in the electronic shift control unit or whenever there is a power failure, the transmission automatically selects "N".

2.5.1 Driving Downhill

When driving down steep gradients, depending on requirements, you should select setting 1, 2, or 3 on the speed range selector. This restricts upshifts.

⚠️ DANGER !
In extreme cases, to protect the engine, the upshift inhibit is disabled.
In such cases, the transmission is able to change up into top gear, regardless of which speed range is selected.
RISK OF ACCIDENT!
Keep a close eye on the tachometer!

2.5.2 Change in Direction of Travel

Before changing from Forward to Reverse or vice versa:

- Vehicle stationary
- Accelerator pedal at idle setting and \( n_{\text{out}} < 900 \) rpm
- Speed range selector in Neutral position, actuate brake pedal if necessary
- Move speed range selector to D, 1, 2, 3, or R
2.5.3 Kick-Down

To utilize max. engine power, higher shift points can be called up using the kick-down switch (see illustration) or the CAN system (to accelerate or to use the accelerator pedal on uphill gradients).

- Depress accelerator pedal right through full throttle pressure point (kick-down position).
2.5.4 Retarder Operation

The retarder is a ratio-dependent hydrodynamic brake which operates without mechanical wear. The retarder should be employed every time the brakes are applied. This extends the life of the service brake. The retarder can be activated manually and/or using the foot controls.

Conditions for retarder operation
(retarder engaged / actuated)

- Accelerator pedal in idle speed setting
- A forward gear must be engaged
- Vehicle speed > approx. 3 km/h

If these conditions are met, the system prevents upshifts (upshift inhibit).

CAUTION
If the accelerator pedal is actuated, the retarder disengages.
The upshift inhibit is cancelled.
The retarder must be switched off:

- On icy roads
- Whenever the oil temperature rises above 150 °C

The max. permitted oil temperature during retarder operation is 150 °C.

Temperature display or temperature warning:
Refer to chapter 2.8 or vehicle manufacturer's Operating Instructions!

- Retarder activation using foot pedal, de-activation using toggle switch on dashboard
- Switch off hand lever whenever the brake has been applied!

⚠️ DANGER!
The retarder is automatically governed back by means of a specified transmission oil temperature characteristics curve. Risk of accident as a result of reduced braking capability!
2.6 Stopping, Parking

NOTE
Only use parking brake when vehicle is stationary.

Stopping
The vehicle can be stopped at any time, regardless of the setting of the speed range selector. The electronic shift control unit then engages the appropriate gear for setting off.

With short stops:
- Speed range can remain selected
- Apply brake

At extended stops:
- Speed range selector in Neutral position
- Apply brake

Transmission with special "Bus Stop Neutral" (NBS) feature
The transmission automatically selects Neutral when the following conditions are in place simultaneously:
- Vehicle stationary
- Brake applied
- Accelerator pedal in idle speed setting

The speed range selector remains in its most recently selected setting.
As soon as any one of the above three conditions ceases to apply, the transmission automatically engages 1st gear.

Parking
- Speed range selector in Neutral position
- Apply parking brake

⚠️ DANGER!
Before leaving the vehicle, always apply the parking brake. When the engine is switched off, there is no direct connection between engine and axle. The vehicle can therefore start to roll!
2.7 Towing

2.7.1 Towing a Vehicle with Operational Transmission

- Speed range selector in Neutral position
- Max. towing time: 2 hours
- Max. towing speed:
  - City and intercity buses: 25 km/h
  - Coaches: 35 km/h

NOTE
At an ambient temperature of less than -15 °C the towing speed is 5 km/h.

2.7.2 Towing a Vehicle With Suspected Transmission Damage

CAUTION
If transmission damage is suspected, flange on universal shaft between transmission and drive axle needs to be disconnected.

Exception: In a dangerous situation, towing is permitted until vehicle leaves the area of immediate danger (e.g. crossroads, tunnel etc.) even without disconnecting the driveline.
2.8 Temperature Monitoring

The transmission temperature monitoring function is performed by the electronic automatic shift system (Ecomat 2 and Ecomat 2 plus) and/or via a temperature indicator (Ecomat).

The actuation point of temperature indicator warning contact is 145 °C.

2.9 Limit Values for Oil Temperature

2.9.1 Transmission Oil Temperature Upstream of Oil Cooler

**During retarder operation:**
- In exceptional cases, short periods of operation (max. 5 mins. within a 1 hour period) at 150 °C are permissible.

**During torque converter operation:**
- The temperature limit for continuous operation is 110 °C.
- In exceptional cases, short periods of operation (max. 5 mins. within a 1 hour period) at 130 °C are permissible.

**During normal driving:**
- The permitted temperature range is between 90 - 100 °C.

### 2.9.2 Oil Temperature in Transmission Sump

**NOTE**
The following sump temperatures must not be exceeded (not even at high ambient temperatures):

<table>
<thead>
<tr>
<th>Transmission oil sump temperatures</th>
<th>Ecomat</th>
<th>Ecomat 2</th>
<th>Ecomat 2 plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>max.</td>
<td>max.</td>
<td>max.</td>
</tr>
<tr>
<td>or continuous temperature</td>
<td>80 - 90 °C</td>
<td>100 °C</td>
<td>105 °C</td>
</tr>
<tr>
<td>Exception: Max. 5 Min. within any 1 hour period</td>
<td>105 °C</td>
<td>105 °C</td>
<td>115 °C</td>
</tr>
</tbody>
</table>
2.9.3 Action When Permitted Oil Temperature Limit is Exceeded

- Driving at part throttle in low driving range
- Switch off retarder

If this does NOT cause the oil temperature to drop:

- Stop the vehicle
- Speed range selector in Neutral position
- Run engine at raised idle speed

NOTE
If the temperature does not drop back into its permitted range within a few minutes, the possible causes are:

- Oil level too low or too high
- Coolant circuit defective
- Transmission damage

Inform ZF Service Center without delay!

2.10 Status Monitoring / Warning Lamps

The diagnosis system on the electronic automatic shift system (the ECU) monitors the transmission status every time the vehicle circuit is switched on and continuously while the vehicle is in motion.

Warning lamps
Faults are displayed by warning lamps lighting up (red or yellow) and by warning messages which appear on the driver's display panel (refer to the vehicle manufacturer's Operating Instructions).

If a selected gear or speed range is not accepted by the ECU, the button pressed on the speed range selector starts to flash.
2.11 Transmission Response to a Malfunction

To protect the transmission in the event of a malfunction, the following responses are provided:

Shift into Neutral:
In the event of major malfunctions in the power supply to the transmission, e.g. short circuit

Shift into Limp-Home Mode:
If there is an interruption to CAN communication or a loss of speed information

⚠️ DANGER!
In the event of a malfunction occurring in the transmission system:
• There is an extremely high risk of transmission damage
• Restricted system monitoring
  RISK OF ACCIDENT!

2.11.1 Limp-Home Mode

The ECU is set up with specific time and pressure settings for pressure control in limp-home mode. Please also note that:

• The retarder function is not available
• The "Bus Stop Neutral" (NBS) function is not available
• The engine brake cannot be activated
• "Torque converter lock-up clutch" (WK) is open
• Engine torque is limited to protect the transmission (no engine management)
2.12 Auxiliary Control Unit

This auxiliary control unit was developed to help with moving the vehicle during the production process and to act as a limp-home facility in the event of ECU failure.

Auxiliary control unit HST 18 (Ecomat)
The HST 18 auxiliary control unit is fitted to the 55-pin connector instead of the ECU18 unit (i.e. the normal ECU). This allows the driver to select one forward and one reverse gear. No gear changes are possible while the vehicle is in motion.

Auxiliary control unit HST 46 (Ecomat 2/ Ecomat 2 plus)
The HST 46 auxiliary control unit is fitted to the 68-pin connector instead of the ECU 46 C / ECU 47 C and/or ECU 146 / ECU 147 units (i.e. the normal ECUs). This allows the driver to select one forwards and one reverse gear. No gear changes are possible while the vehicle is in motion.

2.12.1 Operating Instructions for the Auxiliary Control Unit

- Apply parking brake to prevent vehicle from rolling accidentally.
- Speed range selector in Neutral position (*N*)
- Switch off engine and ignition.
- Remove connector from ECU 46 C / ECU 47 C and/or ECU 146 / ECU 147 control unit.
- Attach connector to HST 18 auxiliary control unit and secure.
- Start engine.
- Engage gear on speed range selector:
  - Shift setting "N" = Neutral
  - Shift setting "D" = Forward (gear is engaged, and no upshifts or downshifts occur)
  - Shift setting "R" = Reverse
DANGER!

When the auxiliary control unit is in operation, none of the safety functions are operational.

RISK OF ACCIDENT!

Please therefore pay careful attention to the following points:

• Shifting from "N" to "D" or from "N" to "R"; only ever possible at idle speed and while vehicle is stationary. The transmission can also perform gear changes at higher engine speeds - however this does lead to transmission damage.

• Before every change from forwards to reverse travel or vice versa, always ensure that the vehicle is completely stationary.

• After shifting into "D" or "R", always wait for 2 seconds to enable the transmission to engage before starting to accelerate.
3 Maintenance

Good maintenance delivers operational reliability for the transmission. It is therefore very important to ensure that all maintenance work required is consistently carried out to the required standard.

⚠️ THREATS TO THE ENVIRONMENT!
Lubricants and cleaning agents must not be allowed to escape into the ground, surface water or the drainage system.
• Ask your local environment agency for safety information on the relevant products and adhere to their requirements.
• Collect used oil in a suitably large container.
• Dispose of used oil, dirty filters, lubricants, and cleaning agents in accordance with environmental protection guidelines.
• When working with lubricants and cleaning agents always refer to the manufacturer’s instructions.

3.1 Oil Grade

CAUTION
When filling Ecomat transmissions, always use oils specified on the latest version of the ZF List of Lubricants TML 14:
• The most recent version of this List of Lubricants can be obtained from all ZF Sales & Service Centers, or can be downloaded from the Internet from www.zf.com (Products for → Technical Information → List of Lubricants).
3.2 Oil Quantities in the ZF-Ecomat

For the initial fill of a dry transmission, approx. 28 liters (dm³)

After installation of new / replacement transmissions, approx. 20 liters (dm³)

After oil changes: After approx. 10 minutes, the following oil quantities are setting

- Ecomat, flat oil pan: approx. 12 dm³
- Ecomat, deep oil pan: approx. 13 dm³
- Ecomat 2, flat oil pan: approx. 17 dm³
- Ecomat 2, deep oil pan: approx. 18 dm³

NOTE
With the optional extra of auxiliary cooling, the oil quantity increases to approx. 2 dm³.

CAUTION
The figures shown here are intended for guidance. In all cases, measurement with the dipstick provides the definitive value.

3.3 Oil Level Check

CAUTION
Achieving the correct oil level is extremely important.

⚠️ DANGER!
Insufficient oil in the system leads to partial or complete failure of the retarder, i.e. braking action is impaired or non-existent.

NOTE
The vehicle must be parked on level ground when checking the oil level.

CAUTION
- Check the oil level at operating temperature to obtain a definitive figure.
- Check the oil level at the quarterly service interval in the workshop.
- Conduct regular visual inspections of the transmission for signs of leakage.
- In exceptional cases the oil level may need to be checked while the transmission oil is cold - refer to Chapter 3.3.2. Then always check the oil again at normal operating temperature.
- If the heat exchanger is arranged above the centerline of the transmission (separate installation), the oil level must be checked in accordance with Chapter 3.3.3.
3.3.1 Checking Oil at Operating Temperature

The definitive temperature reading is always the one obtained from the hot transmission oil (80 to 90 °C).

**Conditions:**
- Park vehicle on level ground
- Move speed range selector into Neutral
- Let engine run at idle speed

After waiting for approx. 2 minutes, the oil level should be up in the hot range.

**CAUTION**
The engine idle speed should be set to between 500 and 700 rpm. It must never drop below 450 rpm.

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3.3.2 Reference Value Calculation

This oil level measurement, carried out while the transmission oil is cold, is applied under the following exceptional circumstances:
- When a transmission enters service for the first time
- After extended stationary periods, e.g. when taking over a third party vehicle
- Following repair work on a vehicle transmission: E.g. removal of the oil pan, hydraulic control unit, oil cooler etc.
- After oil or filter changes

Calculation of the flat rate (labor charge) can be divided into three steps:
- Checking before starting the engine
- Checking after starting the engine

Afterwards, inspection at operating temperature must be performed.
3.3.2.1 Checking Before Starting the Engine

The oil level must be within or above the range called \( n_{\text{eng}} = 0 \).

**NOTE**
If the oil level is higher than this, do not drain any oil!

Stationary range \( n_{\text{eng}} = 0 \) { ... }

3.3.2.2 Checking After Starting the Engine

Run the engine for approx. 3 to 5 minutes at idle speed (speed range selector in Neutral), then check the oil level. The oil level should be inside the defined 30 °C range.

**NOTE**
If the oil level is higher than this, do not drain any oil!

**CAUTION**
After cold starts at sub-zero temperatures, the tip of the dipstick must be immersed at least 10 mm in the oil before considering the oil to have reached operating temperature (to obtain a valid reading). The definitive oil level check (at operating temperature) should be conducted as soon as possible, (refer to Chapter 3.3.1).

Cold range 30 °C { ... }
3.3.3 Checking With Separate Heat Exchanger Mounted Above Centerline of Transmission

Run transmission in Neutral for 15 to 20 seconds at neng = 1200 to 1500 rpm.

NOTE
Within 3 minutes of engine running at idle speed, perform the "Check After Starting the Engine" (Chapter 3.3.2.2) closely followed by the "Check at Operating Temperature" (Chapter 3.3.1).

3.4 Option for Heating Up the Transmission Oil

The transmission oil can be heated up to its specified operating temperature for oil check purposes by running the vehicle, running retarder cycles until the oil sump temperature reaches 80 - 90 °C.

If normal operation of the vehicle is not possible, the oil needs to be heated up in one of the following ways:

- Apply parking brake
- Select speed range "D"
- Apply the service brake
- Run engine several times at part throttle (as required) for 15 to 20 seconds at 1200 to 1500 rpm.

CAUTION
Max. permitted oil temperature upstream of heat exchanger is 110 °C (continuous).

After every heating phase and with the transmission in Neutral, run engine at 1500 to 2000 rpm for 15 to 30 seconds.
Once the oil has reached operating temperature:

- Transmission in Neutral
- Run engine for 2 to 3 minutes

Then check oil level as described in Chapter 3.3.1.

3.5 Oil Change Intervals

The oil change intervals defined in ZF List of Lubricants TE-ML 14 are binding.

NOTE
The latest List of Lubricants can be obtained from all ZF Sales & Service Centers or can be downloaded from the Internet under www.zf.com (Information → Technical Information → List of Lubricants.

CAUTION
The oil filter must be replaced at every oil change.

NOTE
When changing the oil from a mineral-based to a partially synthetic, hydrocracked, or synthetic grade of ATF, it is advisable to conduct an intermediate oil change at the half way point to the next specified service interval.
3.6 Draining the Oil

**NOTE**
Drain the oil - only while at operating temperature and over a period lasting at least 10 minutes.

- Engine must be stationary
- Unscrew oil drain plug (1) and drain oil
- Remove filter cover (2)
- Replace filter cartridge, copper rings, and O-rings

3.7 Filling With Oil

- Fit filter cover (screw tightening torque 25 Nm)
- Screw in oil drain plug (1) (tightening torque 50 Nm)
- Remove dipstick (3)
- Top up oil (for oil quantities, refer to Chapter 3.2)
- Check oil level in accordance with Chapter 3.3
3.8 Draining / Filling Oil on ZF Angle Drive

**NOTE**
The ZF angle drive shares an oil supply with the ZF-Ecomat.

**Oil fill quantity**: approx. 1 dm³

**Oil grade**:  
In accordance with List of Lubricants TE-ML 14 (Chapter 3.1)

**Oil change intervals**:  
In conjunction with the Ecomat transmission

**NOTE**
**Drain the oil**: Only when at operating temperature

**ZF 80° angle drive**  
- Engine must be stationary  
- Unscrew oil drain plug on angle drive and drain oil  
- Screw oil drain plug into angle drive [tightening torque 50 Nm]

**ZF ST 10000 angle drive**  
This angle drive does not have its own oil drain plug. Its oil is drained from the main transmission circuit.
3.9 Checking the Load Sensor Setting (Ecomat)

The setting of the load sensor must be checked:
- After all maintenance on transmission or engine
- If hard shift impacts occur
- At least once every 3 months

Implementing checks
(for this check to be effective, the engine must be at the correct setting)

This level check can be conducted using the marks on the front face or top of the housing.

- **Switch off engine**
- **Apply parking brake**
  - Slowly depress accelerator pedal to its pressure point (full throttle detent on fuel injection pump), press firmly - but do not go past the kickdown point.
  - Maintain accelerator pedal setting; mark on load sensor lever must match the full throttle mark (high) on the housing.
  - Release accelerator pedal until idle speed setting is reached.
  - Mark on load sensor lever must be aligned with idle speed mark (low) on housing.

**CAUTION**
- Do not use detents on load sensor housing for setting purposes.
- Do not unfasten screws on load sensor housing or nut on shaft.
- Check ball heads for wear (excessive clearance) and grease fill.
<table>
<thead>
<tr>
<th>Error</th>
<th>Possible cause</th>
<th>Remedial action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine will not start</td>
<td>Speed range selector not in &quot;Neutral&quot;</td>
<td>Select &quot;Neutral&quot; on speed range selector</td>
</tr>
<tr>
<td></td>
<td>ECU connector loose</td>
<td>Re-establish plug connection</td>
</tr>
<tr>
<td></td>
<td>Starter inhibit relay defective or missing CAN signal</td>
<td>Replace relay or check CAN signal</td>
</tr>
<tr>
<td>Transmission does not engage any gears</td>
<td>Accelerator pedal not in idle speed position or load signal too high</td>
<td>Check or adjust settings of accelerator pedal / fuel injection pump</td>
</tr>
<tr>
<td></td>
<td>Motorleerlaufdrehzahl &gt; 900 min⁻¹</td>
<td>Adjust engine idle speed</td>
</tr>
<tr>
<td></td>
<td>Only on transmissions with additional &quot;gear release&quot; function: Service brake not applied</td>
<td>Apply the service brake</td>
</tr>
<tr>
<td></td>
<td>ECU in malfunction setting</td>
<td>Switch ignition on/off</td>
</tr>
<tr>
<td>Vehicle does not move</td>
<td>Oil level too low</td>
<td>Check / Correct oil level</td>
</tr>
<tr>
<td></td>
<td>Transmission defective</td>
<td>Call ZF Service</td>
</tr>
<tr>
<td>Oil temperature too high</td>
<td>Oil level too high</td>
<td>Check / Correct oil level</td>
</tr>
<tr>
<td></td>
<td>Retarder engaged</td>
<td>Switch off retarder using hand lever</td>
</tr>
<tr>
<td></td>
<td>Internal damage</td>
<td>Call ZF Service</td>
</tr>
<tr>
<td>Retarder not responding</td>
<td>Oil level too low</td>
<td>Check / Correct oil level</td>
</tr>
<tr>
<td></td>
<td>Retarder proportional valve or solenoid valve not operating, CAN signal not present</td>
<td>Check CAN signal</td>
</tr>
</tbody>
</table>