Transmission 26

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Eaton Fuller Manual Transmission

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Removal

- Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
- 2. From inside the cab, remove the shift lever and shift tower from the transmission top cover, as follows. See **Fig. 1**.
 - 2.1 Before removing the shift lever, place the transmission in high gear.
 - If installed, disconnect any electrical connector(s) on the shift lever.
 - 2.3 Remove the four M6 screws from the retaining ring around the shift lever boot. Remove the retaining ring and boot from the cover plate.
 - 2.4 Remove the eight M6 screws from the spring nuts in the cover plate. Remove the cover plate from the cab floor.
 - 2.5 Remove the four 3/8–16 shift tower mounting capscrews from the shift tower. Remove the shift tower and shift lever from the transmission top cover. See Fig. 2.
- 3. If it is necessary to replace the shift lever or components of the shift linkage, disassemble the shift linkage, as follows.
 - 3.1 If it is necessary to replace the shift lever, remove the M10 shift linkage flange screw attaching the shift lever to the shift linkage adaptor. Remove the end of the shift lever from the shift linkage adaptor on the transmission.
 - 3.2 If it is necessary to replace the shift linkage adaptor, remove the M10 shift linkage flange screw attaching the shift linkage adaptor to the shift tower. Remove the shift linkage adaptor from the shift tower.
- 4. From underneath the vehicle, disconnect the driveshaft from the transmission, as follows.
 - 4.1 Support the midship bearing.
 - 4.2 Remove the bolts from the U-joint end caps and slide the front of the driveshaft out of the transmission output yoke. See Fig. 3.

- 4.3 Remove the midship bearing bracket. See Fig. 4.
- 4.4 Support the disconnected driveshaft with a chain. See **Fig. 5**.
- 5. Drain the transmission fluid. See **Fig. 6** for the location of the drain plug.
- 6. Remove the transmission temperature sensor and fitting from the transmission top cover.
- 7. Remove the fuel lines and the fuel line standoff bracket from the transmission. See **Fig. 7**.
- Unplug the electrical connector on the speedometer sensor. Disconnect any other sensors (neutral start switch, back-up switch, etc.), if installed.

WARNING

Do not press down on the clutch pedal after removing the slave cylinder. Clutch hydraulic fluid (DOT 4 brake fluid) may squirt out, causing personal injury and damage to the vehicle.

- Remove the bolts that attach the clutch slave cylinder to the mounting flange on the bell housing. Move the slave cylinder out of the way. See Fig. 8.
- Remove the battery cable bracket(s) around the transmission and move the battery cables out of the way. See Fig. 9.
- 11. Remove the exhaust pipe hanger bracket from the gear case. See **Fig. 10**.
- 12. If the vehicle is equipped with optional dual fuel tanks, remove the fuel cross-over line and its support between the tanks.
- 13. Detach and support the transmission, as follows.
 - 13.1 Except for the top two, remove all the bolts that attach the transmission bell housing to the engine flywheel housing.
 - 13.2 Position a transmission jack under the transmission and raise its support plates against the base of the transmission. See Fig. 11.
 - 13.3 Adjust the support plates to cradle the transmission.
 - 13.4 Using a chain, secure the transmission to the jack.

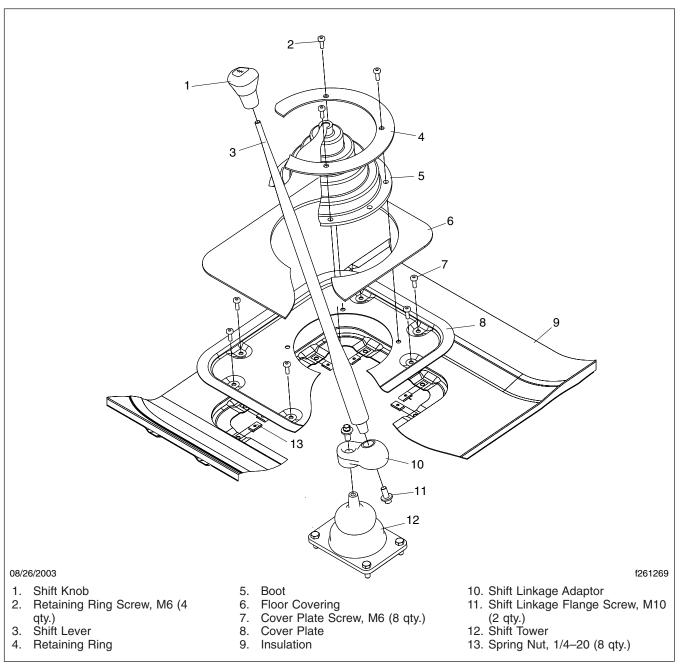


Fig. 1, Shift Lever and Boot

13.5 Remove the last two bolts that attach the bell housing to the flywheel housing.

NOTICE -

Do not allow the rear of the transmission to drop, and do not allow the transmission to hang unsupported. Keep the flange of the bell housing

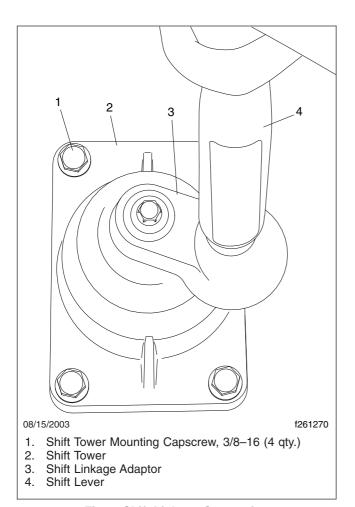


Fig. 2, Shift Linkage Connection

parallel (all the way around) to the flange of the flywheel housing until the input shaft is clear of the flywheel. Taking these precautions will prevent damage to the input shaft, flywheel, and clutch.

- 14. Remove the transmission, as follows. See Fig. 12.
 - 14.1 Pull the transmission and jack straight back until the transmission input shaft is clear of the clutch.
 - 14.2 Pull the transmission away from the vehicle. If there is not enough clearance to allow it to go straight out the back, use the space behind the front wheel on the driver's side.

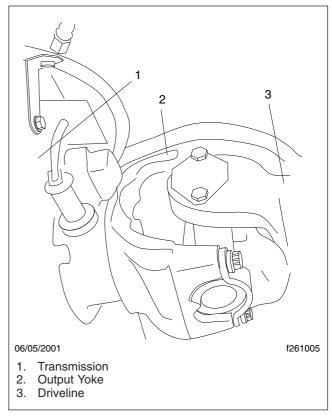


Fig. 3, Output Yoke

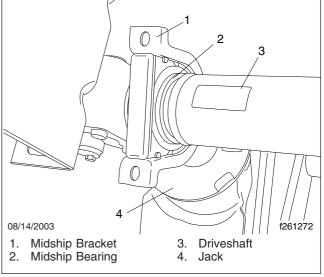


Fig. 4, Midship Bearing Bracket

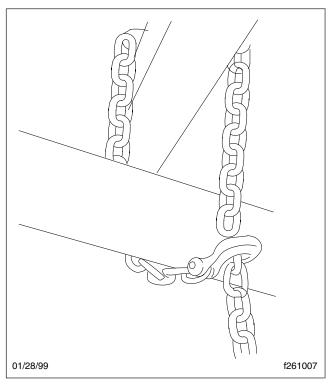


Fig. 5, Supporting the Driveline

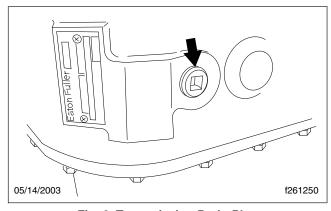
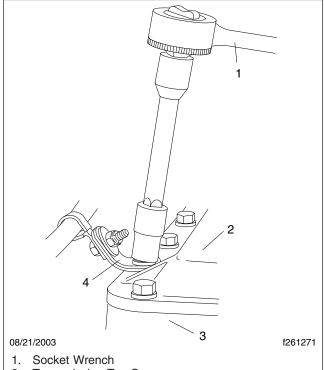


Fig. 6, Transmission Drain Plug

Installation

IMPORTANT: Before installing the transmission, make sure that the rear tires are chocked and that the transmission is securely chained to the support plates on the transmission jack.

1. Install the transmission, as follows.



- 2. Transmission Top Cover
- 3. Gear Case
- 4. Bracket

Fig. 7, Fuel Line Standoff Bracket

- 1.1 Align the jack and the transmission behind the engine. Make sure the fingers of the release yoke are rotated to clear the release bearing housing. See Fig. 13.
- 1.2 Coat the splines of the input shaft with antiseize compound.
- 1.3 Raise the transmission and adjust the angle of the jack until the bell housing and the flange of the flywheel housing are parallel.
- Push the transmission and jack straight forward.

NOTE: Before installing, coat the threads of each bolt with Loctite 262 (or equivalent thread-locking compound).

1.5 Install the capscrews that hold the bell housing to the flywheel housing. Use a crossover pattern. Do a final tightening of the capscrews to 33 lbf-ft (45 N·m).

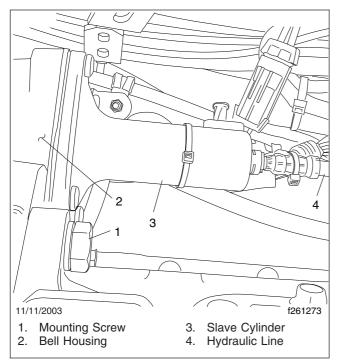


Fig. 8, Hydraulic Clutch Slave Cylinder

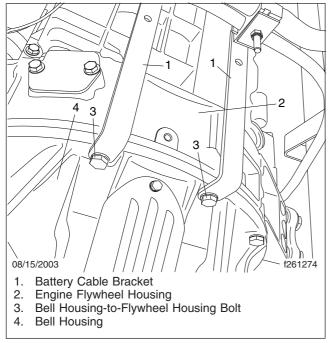


Fig. 9, Battery Cable Brackets

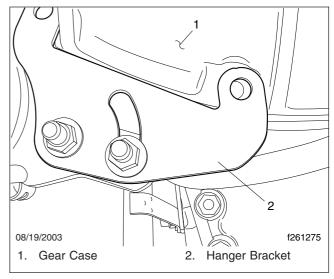


Fig. 10, Exhaust Pipe Hanger Bracket

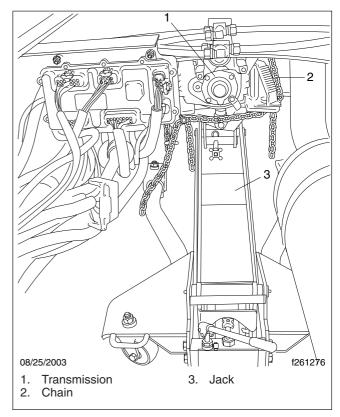


Fig. 11, Supporting the Transmission

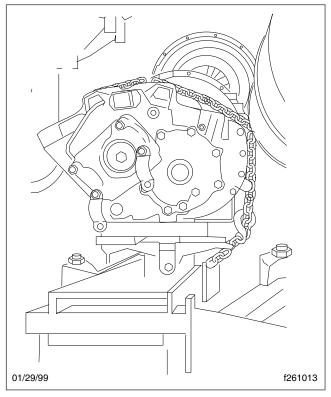
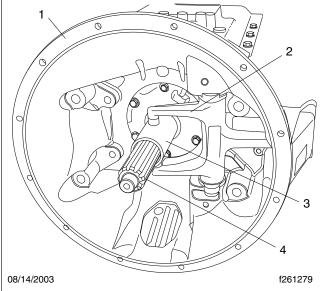


Fig. 12, Removing the Transmission

- 1.6 While installing the bell housing-toflywheel housing capscrews, also install the battery cable brackets, as removed.
- 1.7 Remove the chain that secures the transmission to the jack, then remove the jack.
- Through the inspection opening in the bell housing, make sure the fingers of the release yoke are inserted into the embossed area on the release bearing housing. See Fig. 14.
- If the vehicle is equipped with the optional dual fuel tanks, install the fuel cross-over line and its support between the tanks. Tighten the clamps 40 lbf·ft (54 N·m) and the mounting bolts 95 lbf·ft (129 N·m).
- 4. Connect the driveshaft, as follows.
 - 4.1 Slide the front of the driveshaft into the transmission output yoke.
 - 4.2 Install the U-joint end caps on the output yoke. Tighten the bolt heads 50 lbf·ft (68 N·m) for 3/8-inch end cap bolts and 110 lbf·ft (149 N·m) for 1/2-inch end cap bolts.

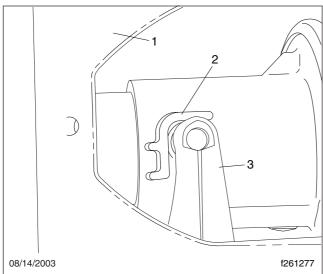


Make sure the fingers of the release yoke are rotated to clear the release bearing.

- 1. Bell Housing
- 2. Release Yoke
- 3. Input Shaft
- 4. Input Shaft Splines

Fig. 13, Installing the Transmission

- 4.3 Install the bolts and nuts on the midship bearing bracket. Tighten the nuts 95 lbf·ft (129 N·m).
- 5. Install the fuel line standoff bracket and connect the fuel lines to the bracket.
- 6. Connect the electrical connectors. Connect the electrical cable to the speedometer sensor.
- 7. If necessary, assemble the shift linkage, as follows. See Fig. 1.
 - 7.1 Before installing, apply three to four drops of Loctite 262 (or equivalent thread-locking compound) halfway down the threads of both shift linkage flange screws.
 - 7.2 Attach the shift linkage adaptor to the shift tower. Tighten the M10 shift linkage flange screw 25 lbf·ft (34 N·m).
 - 7.3 Fit the shift lever onto the remaining hole in the shift linkage adaptor. Tighten the other M10 shift linkage flange screw 25 lbf·ft (34 N·m).



The finger of the release yoke must fit as shown into the embossed area of the release bearing housing.

- 1. Bell Housing
- 2. Embossed Area of Release Bearing Housing
- 3. Finger of Release Yoke

Fig. 14, Release Yoke Alignment

- 8. From inside the cab, install the shift tower and shift lever, as removed, on the transmission top cover. See Fig. 2.
 - 8.1 If removed, connect any electrical connectors to the shift lever.
 - 8.2 Install the cover plate, with spring nuts inserted, on the cab floor. Tighten the eight M6 cover plate screws 60 lbf·in (680 N·cm).
 - 8.3 Install the rubber boot and the metal retaining ring. Tighten the four M6 retaining ring screws 60 lbf·in (680 N·cm).
 - 8.4 Check the position of the shift lever to be sure it is still positioned in high gear, as removed, and that the gears shift normally.
 - 8.5 Tighten the four 3/8–16 shift tower mounting capscrews 30 to 35 lbf-ft (40 to 47 N·m).
- From underneath the vehicle, fasten the clutch slave cylinder, with the plunger fully extended to contact the release yoke, to the mounting flange on the bell housing. Make sure the tab on the

spacer points inboard as shown in **Fig. 15**. Tighten the four mounting bolts 15 lbf·ft (20 N·m).

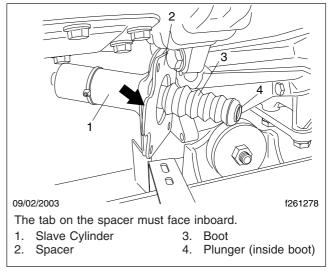


Fig. 15, Slave Cylinder Installation

- If necessary, bleed the hydraulic clutch system. For detailed instructions, see Section 25.02, Subject 140.
- 11. Clean the transmission drain plug and install it on the transmission, along with a new aluminum gasket. Tighten the drain plug 50 lbf·ft (68 N·m).
- 12. Add transmission fluid until it is level with the lower edge of the fill opening. See Fig. 16 for the correct level. See Group 26 of the Business Class® M2 Maintenance Manual for approved transmission lubricants and lubricant capacities.

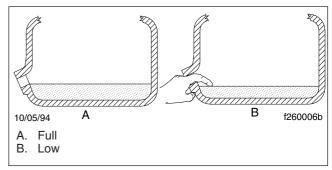


Fig. 16, Transmission Fluid Level Checking

13. Clean the transmission fill plug and install it on the transmission, along with a new aluminum gasket. Tighten the plug as follows:

- 25 to 35 lbf·ft (34 to 48 N·m) for Eaton Fuller transmissions with 3/4-inch pipe threads.
- 60 to 75 lbf-ft (81 to 102 N·m) for Eaton Fuller transmissions with 1-1/4-inch pipe threads.

Specifications

Torque Values, Eaton Fuller Transmissions				
Description	Size	Grade	Torque: lbf·ft (N·m)	Torque: lbf·in (N·cm)
Bell Housing-to-Timing Case Capscrews	M10 x 1.5	8.8	33 (45)	_
Clutch Slave Cylinder Bracket Mounting Bolts	M8	8.8	15 (20)	_
Fuel Cross-Over Line Mounting Bolts	_	_	95 (129)	_
Fuel Cross-Over Line Mounting Clamps	_	_	40 (54)	_
Midship Bearing Bracket Capscrews	3/4-11	_	95 (129)	_
Shift Lever Cover Plate Screws	M6	8.8	_	60 (680)
Shift Lever Retaining Ring Screws	M6	8.8	_	60 (680)
Shift Linkage Flange Screws	M10 x 1.5	8.8	25 (34)	_
Shift Tower Mounting Capscrews	3/8–16	_	30-35 (40-47)	_
Transmission Fluid Drain Plug	_	_	50 (68)	_
Transmission Fluid Fill Plug (with 3/4-inch pipe fittings)	_	_	25-35 (34-47)	_
Transmission Fluid Fill Plug (with 1-1/4-inch pipe fittings)	_	_	60-75 (81-102)	_
	3/8–24	_	50 (68)	_
U-Joint End Cap Bolts	1/2–20	_	110 (149)	_

Table 1, Torque Values, Eaton Fuller Transmissions

26.01

Allison Automatic Transmission

Contents

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Service Operations	
Removal and Installation	
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Removal

- 1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.
- 2. Disconnect the batteries.
- Remove the transmission drain plug from the bottom of the transmission and drain the automatic transmission fluid (ATF). Install the drain plug and tighten it 18 to 24 lbf-ft (25 to 32 N·m).
- 4. Support the driveline with a jack stand between the midship bearing and rear axle.
- Disconnect the driveline from the transmission, as follow.
 - 5.1 Loosen the bolts that attach the midship bearing bracket, so the driveshaft can slide to the rear. See **Fig. 1**.

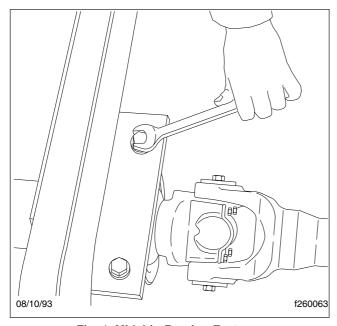


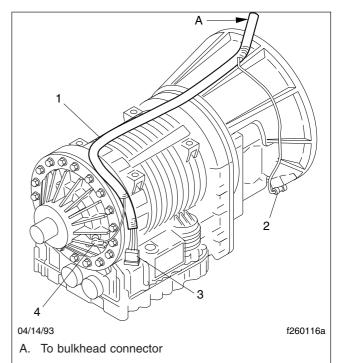
Fig. 1, Midship Bearing Fastener

- 5.2 Remove the transmission yoke U-joint end caps or lock straps. Separate the driveline from the transmission output yoke.
- 5.3 Remove the driveline companion flange from the transmission companion flange.

NOTE: It may be necessary to remove the mounting bolts from the midship bearing

bracket so the driveshaft can be moved far enough back.

- 5.4 Support the disconnected driveshaft and tie it to the frame rail.
- Disconnect the three electrical connections to the transmission. See Fig. 2. For instructions, see Subject 120.



- 1. Transmission Wiring Harness
- 2. Engine Speed Sensor
- 3. Transmission Control Connector
- 4. Output Speed Sensor

Fig. 2, Transmission Electrical Connections

- 7. Remove the ATF fill/dipstick tube, as follows.
 - 7.1 Remove the capscrew and clamp that hold the fill/dipstick tube.
 - 7.2 Pull the fill/dipstick tube out of the transmission case.
 - 7.3 Plug the hole with a clean shop towel to prevent entry of foreign material.
- 8. Disconnect the flexplate from the transmission, as follows.

8.1 Remove the capscrews that attach the ring gear access cover, then remove the cover. See **Fig. 3**.

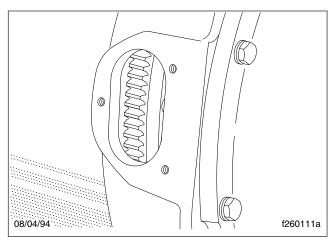
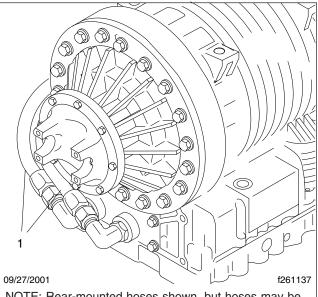


Fig. 3, Ring Gear Access

NOTE: For easier access on Mercedes-Benz engines, first remove the three bolts that hold the exhaust pipe to the turbocharger exhaust elbow, then lower the exhaust pipe.

- 8.2 Using a screwdriver, turn the ring gear until one of the capscrews that attach the flexplate adapter to the torque converter can be removed. Continue turning the ring gear and removing the capscrews through the access hole until all 12 are removed.
- Disconnect the transmission fluid cooler lines from the transmission, and drain the remaining ATF. See Fig. 4.
- 10. Place a piece of plywood on a transmission jack to support the transmission.
- Slide the jack into place under the transmission. Secure the transmission with a chain. Anchor the chain with bolts at the front lifting bosses on the top of the transmission. See Fig. 5.
- 12. If equipped, remove the two bolts that attach the transmission to the rear overslung transverse support spring. Remove the spring. See **Fig. 6**.
- 13. Remove the 12 transmission-flange bolts. See Fig. 7.
- 14. Remove the muffler support bracket that is supported by two of the companion-flange bolts.



NOTE: Rear-mounted hoses shown, but hoses may be attached at the front of the transmission.

1. ATF Cooler Hoses

Fig. 4, Fluid Cooler Lines

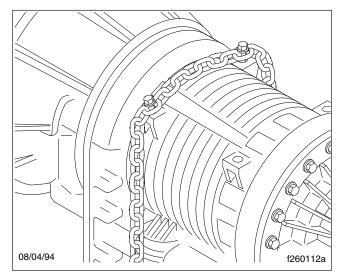


Fig. 5, Chain Around Transmission

15. Move the transmission jack to the rear. Lower the jack and lift the vehicle, as needed, so the transmission clears the frame rail and any attached components. Support the vehicle frame with jack stands.

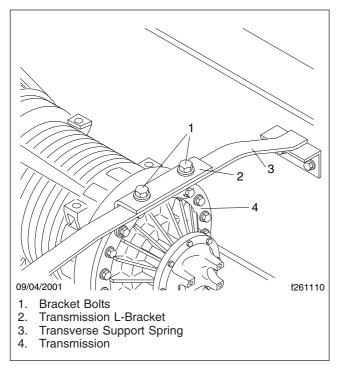


Fig. 6, Transverse Support Bracket

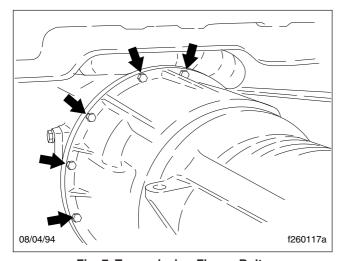


Fig. 7, Transmission-Flange Bolts

Roll the transmission jack rearward, and remove the transmission.

Installation

IMPORTANT: Before installing the transmission, make sure the rear tires are chocked and the

transmission is securely chained to the transmission jack.

- Raise the vehicle frame with a hydraulic jack to obtain adequate clearance for installing the transmission. Place jack stands under the front of the vehicle.
- 2. With the transmission on a jack, roll the transmission into place behind the flexplate. Remove the jack stands, and lower the vehicle frame.
- 3. Raise the jack until the transmission lines up with the flexplate.
- 4. Push the transmission toward the engine until it seats squarely against the engine flywheel housing, with the bolt holes in the transmission housing aligned with those in the flywheel housing.

NOTE: No force is required. If interference is encountered, move the transmission away from the engine and correct the problem.

- 5. Install the transmission-flange bolts finger-tight.
- Install the 12 flexplate adapter capscrews, as follows.
 - 6.1 Turning the ring gear for access, install all the capscrews through the access hole. Don't tighten them now.

Be careful not to drop the capscrews inside the flywheel housing. The transmission must be removed to get them out.

IMPORTANT: Install all capscrews before tightening any of them to prevent cocking of the flexplate adapter.

- 6.2 Tighten the capscrews, in a star pattern, to the following specifications based on the model number:
 - 1000 and 2000 Families: 6 bolts to 46 lbf-ft (62 N·m)
 - 3000 Family: 6 bolts to 50 lbf·ft (68 N·m)
 - 4000 Family: 12 bolts to 27 lbf-ft (37 N·m)
- 6.3 Install the access cover and its capscrews. There are four capscrews on Caterpillar engines, three capscrews on Mercedes-Benz engines, and two on Cummins and Detroit Diesel engines.

- 7. Tighten the 12 M10 transmission-flange bolts 38 to 45 lbf·ft (51 to 61 N·m) in a star pattern. See Fig. 7.
- 8. If previously removed, install the transverse support spring at the rear of the transmission. Install the two bolts and washers. Tighten the bolts 136 lbf·ft (184 N·m). See **Fig. 6**.
- Remove the chain that holds the transmission to the transmission jack.
- 10. Lower the transmission jack and remove it.
- Connect the transmission fluid cooler hoses to the transmission, and tighten the fittings to the applicable values in Table 1. See Fig. 4.
- 12. Install the muffler bracket.
- 13. Connect the driveshaft, as follows.
 - 13.1 Slide the front of the driveshaft into the transmission output yoke.
 - 13.2 Install the transmission yoke U-joint end caps and lock straps.
 - 13.3 If the midship bearing bracket bolts and nuts were removed, install them. Tighten the nuts 95 lbf·ft (129 N·m).
- On Mercedes-Benz engines, if the exhaust pipe was disconnected from the turbocharger exhaust elbow, connect the pipe and tighten the bolts 60 lbf·ft (81 N·m).
- 15. Install the ATF fill/dipstick tube, as follows.
 - 15.1 Inspect the fill/dipstick tube seal. Replace it if damaged.

- 15.2 Install the fill/dipstick tube and clamp. Tighten the self-tapping screw until it is firmly seated, approximately 18 to 21 lbf·ft (24 to 28 N·m).
- Install the standoff bracket on the right side of the transmission.
 - Make sure the air line and the wiring harness are securely attached to the standoff bracket.
- Connect all electrical lines to the transmission, as follows.
 - 17.1 Connect the transmission control connector.
 - 17.2 Connect the cable to the output speed sensor
 - 17.3 Connect the cable to the engine speed sensor.
 - 17.4 Using tie straps, secure the cables where necessary.
- 18. Fill the transmission with ATF.
- 19. Connect the batteries.
- Start the engine, and check for any leaks. Repair leaks as needed.
- 21. Check the ATF level. Add fluid as needed.
- 22. Remove the chocks from the tires.
- 23. Road test the vehicle, and check for correct transmission operation.

Torque Values for Transmission Fluid Cooler Hoses				
Series/Family	Description	SAE Size	Torque: lbf·ft (N·m)	
1000 and 2000	Front Ports	12	25–35 (34–47)	
	Non-retarder, Front Ports	12	25–35 (34–47)	
3000	Non-retarder, Rear Ports	16	40-50 (54-68)	
	Retarder, Rear Ports	16	40-50 (54-68)	
	Non-retarder, Front Ports	16	40-50 (54-68)	
4000	Non-retarder, Rear Ports	16	40-50 (54-68)	
	Retarder, Rear Ports	20	50-60 (68-81)	

Table 1, Torque Values for Transmission Fluid Cooler Hoses

ATF Cooler Replacement (stand-alone unit)

- NOTICE ----

If the cooler is being replaced due to a failure that allowed coolant and AFT to mix, cleaning contamination from the transmission is necessary. Failure to do so can lead to a transmission failure.

Allison automatic transmissions: It is required to test the transmission fluid for contamination. The presence of water and/or any trace of ethylene glycol coolant mixtures in the transmission oil in an Allison transmission is detrimental to the internal components. Refer to the Allison service literature for more information and proper procedures, or contact an authorized Allison service facility.

Standard transmissions: The presence of water and/or ethylene glycol coolant mixtures in the lubricant in standard transmissions decreases the effectiveness of the lubricant and causes rust and wear to internal parts. If contamination is detected, refer to the transmission manufacturer's service literature for proper procedures.

NOTE: If the vehicle is equipped with the integral radiator/cooler, see **Section 20.01** for replacement instructions.

Replacement

 Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the tires.

A WARNING

Drain the coolant system only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

- 2. With the engine cool, loosen the surge tank cap to release cooling system pressure.
- Place a suitable container under the radiator.
 Open the drain petcock at the bottom of the radiator and drain the cooling system. Close the drain petcock.
- 4. Remove the two radiator hoses at the transmission cooler, draining any excess engine coolant into a pan.

A CAUTION —

The transmission fluid hoses at the cooler have quick-connect fittings. DO NOT attempt to unscrew the fitting at the cooler. It is welded to the cooler. See Fig. 1. If the fittings at the cooler are turned, internal cooler leakage will occur which can cause transmission failure.

- 5. Disconnect the coolant hoses from the fittings at both sides of the automatic transmission fluid (ATF) cooler.
 - 5.1 Pull back the safety collar on the hose fitting accessing the retaining clip. See Fig. 2.

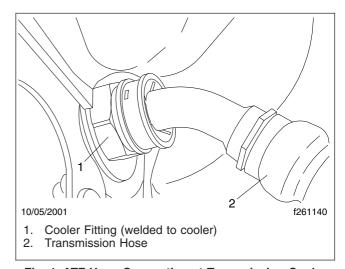


Fig. 1, ATF Hose Connection at Transmission Cooler

5.2 Using a small flat-head screw driver, remove the retaining clip from the cooler fitting. See Fig. 3. Discard the clip.



Protect the ends of the cooler hoses. Failure to do so can cause damage to the hose end, which can tear the internal O-ring at the cooler fitting. If the O-ring tears and leaks ATF, the cooler will have to replaced.

5.3 Over a drain pan, pull the cooler hose out of the fitting. See **Fig. 4**. Catch the ATF by directing the disconnected end of each hose into a drain pan. When the ATF stops draining, plug the hoses.

ATF Cooler Replacement (stand-alone unit)

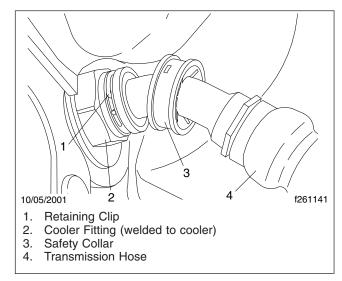


Fig. 2, Safety Collar Removal

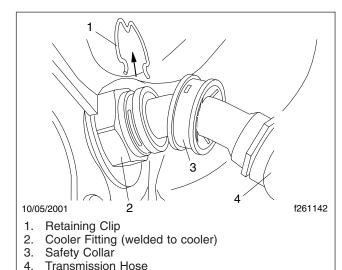
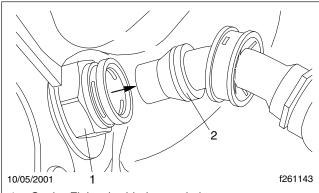


Fig. 3, Retaining Clip Removal

Protect the ends of the cooler hoses, wrapping them in shop towels or similar material.

- Remove the four fasteners that attach the ATF cooler to the mounting bracket assembly, and remove the ATF cooler. Drain the ATF cooler into a drain pan.
- 7. Hold the ATF cooler in place; then install the fasteners on the mounting bracket. Tighten the fasteners 28 lbf·ft (38 N·m).



- 1. Cooler Fitting (welded to cooler)
- 2. Transmission Hose End (protect when removed)

Fig. 4, Cooler Hose Removal

8. Attach the transmission hoses to the fittings at both sides of the cooler.



DO NOT reuse the retaining clips. Use a new retaining clip each time the hoses are removed. Failure to do so could result in the cooler hoses coming out of the cooler during vehicle operation, leaking ATF and causing permanent damage to the transmission. New retaining clips are available from the PDCs.

- 8.1 Install a new retaining clip in the fitting at the cooler. The clip should be completely seated as it was before the hose was removed.
- 8.2 Carefully insert the end of the transmission hose into the cooler fitting until the end seats at the retaining clip. See Fig. 5. Gently pull the hose to make sure it is fully seated.
- 8.3 Push the safety collar back up and around the cooler fitting and retaining clip. See Fig. 1.
- 9. Install the two radiator hoses and tighten the hose clamps.
- Fill the coolant system and install the surge tank cap.
- 11. Start the engine and operate the transmission for 1 or 2 minutes, then add the correct ATF to the transmission as needed. For instructions and lu-

ATF Cooler Replacement (stand-alone unit)

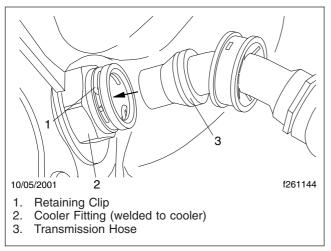


Fig. 5, Transmission Hose Installation

bricant specifications, see Group 26 of the *Business Class M2 Maintenance Manual*.

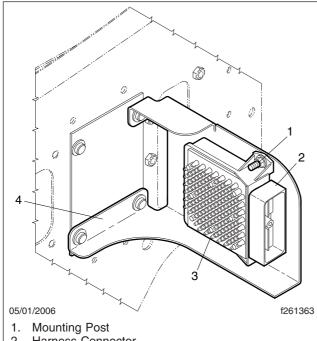
- 12. Check the coolant level and add as needed.
- 13. Remove the tire chocks.

Transmission ECU Replacement

A new transmission control module (TCM) was introduced by Allison Transmissions in mid-2006. This control - known as "fourth generation" - replaced the previous electronic control unit (ECU) that is commonly referred to as "WTEC III". Replacement procedures for both are provided below.

Fourth Generation TCM Replacement

- 1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
- 2. Disconnect the batteries.
- 3. Open the hood and locate the TCM attached to the frontwall panel.
- 4. Disconnect the electrical harness from the TCM. See Fig. 1.



- 2. Harness Connector
- 3. TCM
- 4. Mounting Plate

Fig. 1, Allison Fourth Generation Transmission TCM

5. Remove the nuts and washers from each TCM mounting post, then remove the TCM.

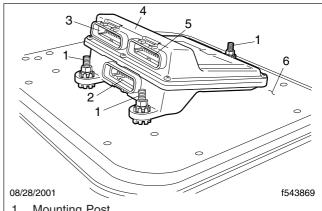
6. Place the new TCM over the mounting posts, and install the washers and nuts. Tighten the nuts 24 lbf·in (271 N·cm).

IMPORTANT: Be careful when attaching the 80way connector to the TCM. Do not bend the pins.

- Connect the electrical harness to the TCM.
- Connect the batteries.
- 9. Close the hood and remove the chocks from the tires.

WTEC III ECU Replacement

- 1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the
- Disconnect the batteries.
- 3. Locate the ECU either on the frame or behind the left fender, and disconnect the black, gray, and blue harness connectors from the ECU.
- Remove the nuts, washers, and spacers from each ECU mounting post, and remove the ECU. See Fig. 2.



- Mounting Post
- Blue Harness Connector Port
- Black Harness Connector Port
- **ECU**
- Gray Harness Connector Port
- ECU Access/Mounting Plate

Fig. 2, Allison WTEC III Transmission ECU

5. Place the new ECU over the mounting posts and install the spacers, washers, and nuts. Tighten the nuts firmly.

Transmission ECU Replacement

- Connect the blue, black, and gray electrical harnesses to the appropriate ports on the ECU.
- 7. Remove the chocks from the tires.

26.02

SmartShift[™] Transmission Shift Control

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General Information

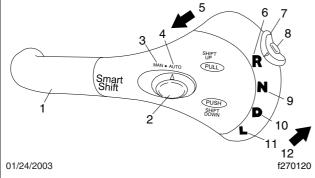
General Information

The SmartShift[™] transmission shift control is an electronic transmission control device. It is required with the following automated transmissions:

- Eaton® Fuller® UltraShift™
- Eaton Fuller UltraShift™ PLUS
- Eaton Fuller AutoShift™
- ZF Meritor[™] FreedomLine[™]
- Meritor[™] SureShift[™]
- Mercedes-Benz AGS

There are three versions of the control:

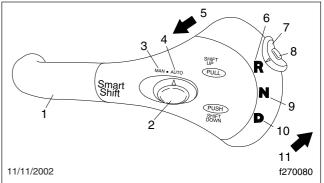
- See Fig. 1 for the UltraShift, UltraShift PLUS, and AutoShift control.
- See Fig. 2 for the FreedomLine and AGS control.
- See Fig. 3 for the SureShift control.



To upshift manually, pull the lever up (towards you). To downshift manually, push the lever down (away from you).

- 1. SmartShift Control Lever
- 2. Slide Switch (forward driving mode switch)
- 3. MAN Mode (of slide switch)
- 4. AUTO Mode (of slide switch)
- 5. Upshift Direction
- 6. Reverse Position (of selector switch)
- 7. Selector Switch
- 8. Neutral Lock Button
- 9. Neutral Position (of selector switch)
- 10. Drive Position (of selector switch)
- 11. Low Position (of selector switch)
- 12. Downshift Direction

Fig. 1, SmartShift Control (with Eaton Fuller UltraShift, UltraShift PLUS, and Autoshift)



To upshift manually, pull the lever up (towards you). To downshift manually, push the lever down (away from you).

- 1. SmartShift Control Lever
- 2. Slide Switch (forward driving mode switch)
- 3. MAN Mode (of slide switch)
- 4. AUTO Mode (of slide switch)
- 5. Upshift Direction
- 6. Reverse Position (of selector switch)
- 7. Selector Switch
- 8. Neutral Lock Button
- 9. Neutral Position (of selector switch)
- 10. Drive Position (of selector switch)
- 11. Downshift Direction

Fig. 2, SmartShift Control (with ZF Meritor FreedomLine and Mercedes-Benz AGS)

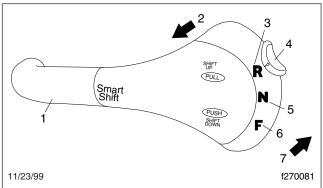
The SmartShift control replaces either the typical floor-mounted shift lever or dash-mounted pushbutton control. It mounts to the right-hand side of the steering column and is operated by the driver's right hand. SmartShift accepts driver requests for transmission functions and transmits them through hard wiring to the transmission control unit (TCU). SmartShift is a true shift-by-wire system.

On SmartShift as designed for UltraShift, UltraShift PLUS, AutoShift, FreedomLine, and AGS, a two-position slide switch allows the driver to choose automatic (AUTO) or manual (MAN) mode.

NOTE: With SureShift, there is no slide switch.

In AUTO mode, gears shift automatically, without driver interaction. In MAN mode, the driver has direct control over gear shifts. Manual gear shifts are accomplished by a momentary pull or push on the control lever in the plane perpendicular to the steering wheel. See **Fig. 4**. All shifts into reverse (R) are done manually.

General Information

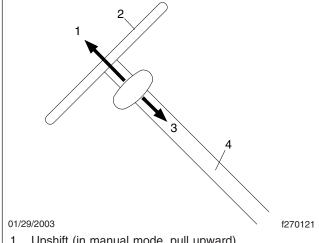


To upshift manually, pull the lever up (towards you). To downshift manually, push the lever down (away from

NOTE: Shown without neutral lock button. Newer Sure-Shift models have a "D" (for drive) in place of the "F" (for forward).

- SmartShift Control Lever 1.
- **Upshift Direction** 2.
- Reverse Position (of selector switch)
- Selector Switch
- Neutral Position (of selector switch)
- Forward Position (of selector switch)
- 7. Downshift Direction

Fig. 3, SmartShift Control (with Meritor SureShift)



- 1. Upshift (in manual mode, pull upward)
- Steering Wheel 2.
- Downshift (in manual mode, push downward)
- Steering Column

Fig. 4, SmartShift Control Lever Operation

Pull upward (toward vou) on the control lever to upshift and push downward (away from you) to downshift. The lever is spring-loaded and returns to midposition when released after an upshift or downshift.

The selector switch is located at the end of the control lever. There are three different versions:

- For UltraShift, UltraShift PLUS, and AutoShift, the four-position selector switch is marked "R-N-D-L". See Fig. 1.
- For FreedomLine and AGS, the three-position selector switch is marked "R-N-D". See Fig. 2.
- For SureShift, the three-position selector switch is marked "R-N-F" (older models) or "R-N-D" (newer models). See Fig. 3.

For UltraShift, UltraShift PLUS, FreedomLine, and AGS, embedded in the selector switch is a small neutral lock button to prevent accidental shifts into gear from neutral. Any time you shift through N, press down on the neutral lock button to move the switch from neutral (N) to another gear. When shifting to N, it is not necessary to press the neutral lock button. For AutoShift and SureShift, all models built after November 2002 have the neutral lock button.

Replacement

Replacement

- Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
- 2. Remove the steering column covers. For instructions, see **Section 46.02**, **Subject 110**.
- Disconnect the electrical connector from the SmartShift module.
- 4. Remove the three mounting capscrews and washers that attach the bracket assembly to the steering column. See Fig. 1.

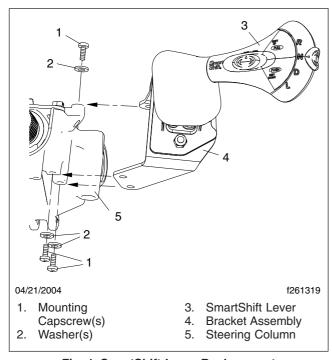


Fig. 1, SmartShift Lever Replacement

- Remove the bracket assembly from the vehicle with the SmartShift lever attached.
- Position the new bracket assembly on the steering column. Install the mounting capscrews and washers. Tighten the capscrews 80 lbf-in (900 N-cm).
- 7. Connect the electrical connector to the SmartS-hift module.
- 8. Install the steering column covers, as removed.

NOTE: For troubleshooting Mercedes-Benz AGS transmissions, see **Section 26.03**, **Subject 302**.

General Information

The following information is provided to help determine whether a problem is with the transmission or the SmartShift® Transmission Shift Control.

Resistance checks at the SmartShift connector can help determine connection problems.

DataLink Software can be used to test the SmartShift control. The tests require a ServiceLink computer connected to the vehicle. If the tests confirm the shift control is defective, this subject also includes connector resistance checks to rule out wiring issues.

For transmissions other than Mercedes-Benz Automated Gear Shift (AGS), follow the procedures below for resistance checking and Freightliner SmartShift testing using DataLink Monitor and dash displays. For AGS transmissions, see **Section 26.03**, **Subject 302**.

To determine which transmission is installed on the vehicle, check the shift pattern decal on the dash or visor.

NOTE: SmartShift controls designed for one transmission model should not be used with other models of transmission.

For Eaton Fuller UltraShift, UltraShift PLUS, and AutoShift, the four-position selector switch is marked "R-N-D-L". A slide switch is present. See Fig. 1.

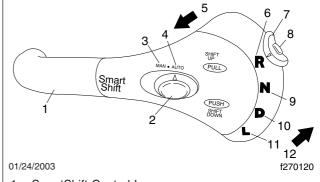
For Meritor SureShift, the three-position selector switch is marked "R-N-F" (older models) or "R-N-D" (newer models). In addition, there is no slide switch. See **Fig. 2**.

For ZF Meritor FreedomLine and Mercedes-Benz AGS, the three-position selector switch is marked "R-N-D". A slide switch is present. See **Fig. 3**.

Shift Control Resistance Checking

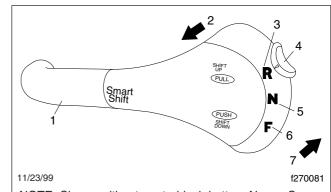
Parts

See Table 1 for parts.



- 1. SmartShift Control Lever
- 2. Slide Switch (forward driving mode switch)
- 3. MAN Mode (of slide switch)
- 4. AUTO Mode (of slide switch)
- 5. Upshift Direction
- 6. Reverse Position (of selector switch)
- 7. Selector Switch
- 8. Neutral Lock Button
- 9. Neutral Position (of selector switch)
- 10. Drive Position (of selector switch)
- 11. Low Position (of selector switch)
- 12. Downshift Direction

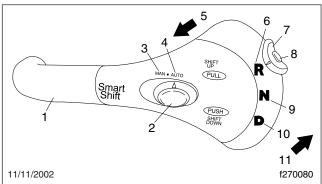
Fig. 1, SmartShift Control (with Eaton Fuller UltraShift, UltraShift PLUS, and AutoShift)



NOTE: Shown without neutral lock button. Newer Sure-Shift models have a "D" (for drive) in place of the "F" (for forward).

- 1. SmartShift Control Lever
- 2. Upshift Direction
- 3. Reverse Position (of selector switch)
- 4. Selector Switch
- 5. Neutral Position (of selector switch)
- 6. Forward Position (of selector switch)
- 7. Downshift Direction

Fig. 2, SmartShift Control (with Meritor SureShift)



- 1. SmartShift Control Lever
- 2. Slide Switch (forward driving mode switch)
- 3. MAN Mode (of slide switch)
- 4. AUTO Mode (of slide switch)
- 5. Upshift Direction
- 6. Reverse Position (of selector switch)
- 7. Selector Switch
- 8. Neutral Lock Button
- 9. Neutral Position (of selector switch)
- 10. Drive Position (of selector switch)
- 11. Downshift Direction

Fig. 3, SmartShift Control (with ZF Meritor FreedomLine and Mercedes-Benz AGS)

Parts for Wire Extension*				
Part Number	Description	Qty.		
PAC12110847	Metri-Pack Terminal	3		
PAC12047767	Connector Terminal	3		
48-02493-184	18GA GTX Wire, Yellow	3 ft x 3		
PAC12047781	3-Pin Connector	1		
PAC12047783	Connector Lock	1		

^{*} Parts are available through the PDCs.

Table 1, Parts for Wire Extension

Procedure

- Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
- 2. Remove the screws that secure the steering column trim panels, and separate the forward and rear panels to access the shift control. See Fig. 4.
- 3. Disconnect the electrical connector from the plug on the shift control unit. See **Fig. 5**.

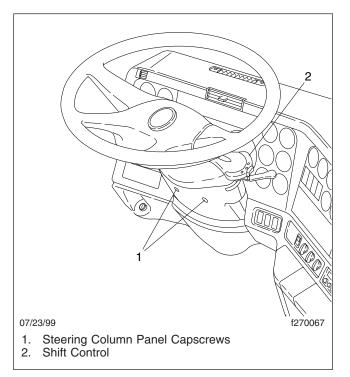


Fig. 4, Steering Column

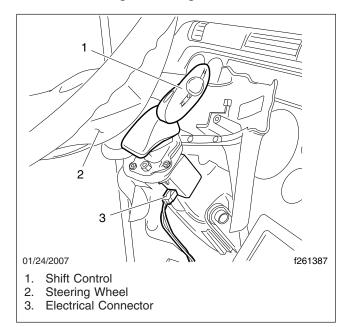


Fig. 5, SmartShift Components

- Assemble the wire extension from the parts in Table 1 to allow for easy resistance testing, as follows.
 - 4.1 Crimp the connector terminals at the end of each 3-foot (1-meter) wire.
 - 4.2 Assemble the 3-pin connector with the connector terminals and connector lock.
 - 4.3 Crimp the Metri-Pack terminals on the other end of the wires.
- Plug the wire extension into the plug on the shift control unit. See Fig. 6 for SmartShift terminal positions.

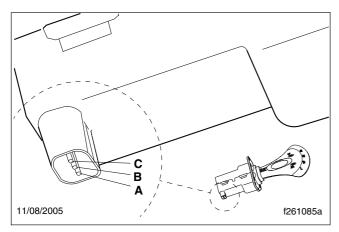


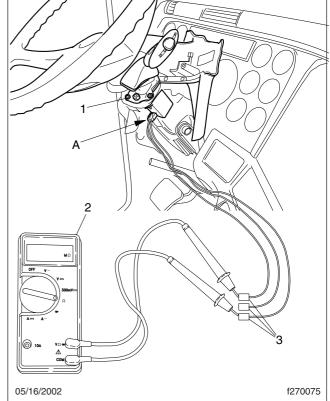
Fig. 6, SmartShift Terminal Positions

NOTE: Using this new wire extension prevents the need to remove the shift control.

6. Check the resistance at the other end of the wires. See Fig. 7.

Use **Table 2** and **Table 3** for all SmartShift applications except Meritor SureShift.

Use **Table 4** for Meritor SureShift applications.



- A. Plug the newly assembled wire extension into the plug on the shift control unit.
- 1. Shift Control Unit
- 2. Digital Multimeter (set to ohms)
- 3. Metri-Pack Terminals (at wire ends)

Fig. 7, Resistance Checking at Shift Control

Resistance on SmartShift Controls at B and C (Except Meritor SureShift)				
Selector Switch Position	Reading: kOhm			
R	2.947-3.067			
N	0.347-0.361			
D	0.606-0.630			
L*	1.65–1.72			

^{*} Applies to four-position (R-N-D-L) controls only.

Table 2, Resistance on SmartShift Controls at B and C (Except Meritor SureShift)

Resistance on SmartShift Controls at A and C (Except Meritor SureShift)				
Slide Switch + Lever Position	Reading: kOhm			
Manual	2.865–2.981			
Manual + Up	0.531-0.553			
Manual + Down	1.150–1.197			
Auto	11.27–11.73			

Table 3, Resistance on SmartShift Controls at A and C (Except Meritor SureShift)

Resistance on the SmartShift Control, Meritor SureShift				
Selector Switch + Lever Position	Reading: kOhm			
R	10.2–10.6			
N	1.65–1.71			
F or D	2.65–2.75			
R + Up	4.14–4.3			
R + Down	6.07–6.31			

Table 4, Resistance on SmartShift Controls at A and C (Meritor SureShift)

- After checking the resistance, unplug the wire extension, and reconnect the electrical connector
- 8. Install the steering column trim panels.

SmartShift Control Checking Using DataLink Monitor (DLM)

- 1. With the wheels chocked, start the engine.
- Connect the service computer to the engine and start ServiceLink.
- Click on the **Transmission** icon on the left screen.
- 4. Click on the **Templates** tab. An overview of available templates will be shown.
- If the vehicle is equipped with Eaton Fuller Auto-Shift, UltraShift, or UltraShift PLUS, click on Eaton AutoShift. If the vehicle is equipped with Meritor SureShift, click on ZF Meritor SureShift.

NOTE: The DLM template for the SureShift transmission will not work with the ZF Meritor FreedomLine transmission. For further diagnostic assistance on FreedomLine transmissions, use Meritor's TransSoft software.

6. Go directly to the appropriate heading in this subject, "SmartShift Control Testing for Eaton AutoShift" or "SmartShift Control Testing for Meritor SureShift and FreedomLine".

SmartShift Control Testing for Eaton AutoShift

The AutoShift DataLink Monitor template (see Fig. 8) will display the current vehicle status and will reflect change in status. Vehicle information is retrieved from the transmission ECU on the datalink. The monitor can also be used to verify readings on the instrument panel.

NOTE: To test the shift control using the datalink, the vehicle can be placed into a mode that allows the gears to be shifted without the engine running. The following step explains how to enter that mode.

- Turn the ignition OFF, then turn the ignition back ON, but don't start the engine. The transmission controller will still be in the Engine ON mode, thereby allowing the gears to be shifted.
- Test the operation of the shift control for Reverse (R) and Neutral (N), as follows.
 - 2.1 Select R on the selector switch. In the Range Selected field of the template an R should be displayed.
 - 2.2 Select N on the selector switch. In the Range Selected field of the template an N should be displayed.
- 3. Test the operation of the shift control for Drive (D), as follows.
 - 3.1 Select D on the selector switch and move the slide switch (reading "MAN/AUTO") to AUTO. In the *Range Selected* field of the template, a D should be displayed.
 - 3.2 With the selector switch still on D, toggle the slide switch from AUTO to MAN and back. Confirm that the *Range Selected* field shows a D while in AUTO and an H (High) while in MAN.

Troubleshooting

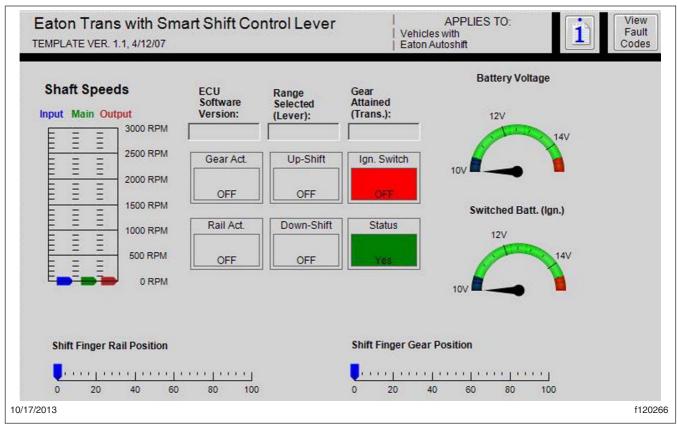


Fig. 8, DataLink Monitor Template for Eaton AutoShift

- 3.3 While in Manual mode, change the selector switch to L (Low) and confirm that the Range Selected field changes from H to L.
- 4. Test upshifting and downshifting, as follows.
 - 4.1 With the selector switch on D, pull and hold the shift control lever. The *Up-Shift* field will turn green and read ON for 3 seconds.
 - 4.2 Push and hold the shift control lever. The Down-Shift field will turn green and read ON for 3 seconds.

NOTE: A blinking display indicates that the transmission is attempting to shift into the gear position. A solid display shows the current gear position attained.

When the selector switch is in any position but N (Neutral), the *Status* field on the Monitor template will read YES.

SmartShift Control Testing for Meritor SureShift and FreedomLine

The SmartShift control test for a Meritor SureShift system can be performed by using the dash-mounted gear display. The SureShift DataLink Monitor (DLM) template can be used if further testing of the system is necessary, for example, to confirm dash display readings or gear positions. See Fig. 9.

NOTE: The DLM template for the SureShift transmission will not work with the FreedomLine transmission. For further diagnostic assistance on FreedomLine transmissions, use Meritor's TransSoft software.

Troubleshooting

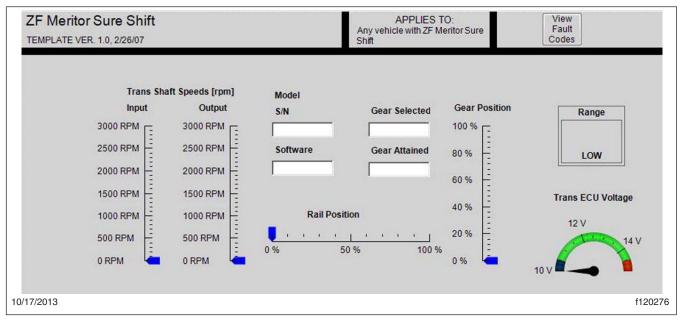


Fig. 9, DataLink Monitor Template for ZF Meritor SureShift

WARNING

For SureShift transmissions, do not depress the clutch pedal during these tests. Doing so could result in the vehicle moving, possibly causing vehicle damage or personal injury.

Make sure all tires are chocked and the parking brake is set before performing the following tests. These tests require the vehicle to be started, and precautions need to be taken to ensure the vehicle will not move.

- 1. Test the operation of the shift control for Reverse (R) and Neutral (N), as follows.
 - 1.1 Move the selector switch to R. Confirm that the display is changing from N to RL (Reverse Low), the default reverse gear. The display will change to CL (Clutch) after one second. Repeat this step if the reading disappeared quickly.
 - 1.2 Pull the shift control lever once to upshift to High Reverse. Confirm the display changes to RH (Reverse High).
- Test the operation of the shift control for F or D, as follows.
 - Move the selector switch to F (Forward) or Drive (D).

2.2 Test upshifting and downshifting. Push, then pull, the shift control lever through all the gears and verify that each gear displays correctly on the dash display.

If the display or the DLM template does not confirm the SmartShift control position, the shift control should be tested. See the shift control resistance checking procedure herein.

Freightliner AMT³ and Mercedes-Benz Automated-Manual Transmissions

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General Information

General Information

Mercedes-Benz AGS Automated Gear Shift transmissions are fully automated manual transmissions that were installed on M2 vehicles for years. In 2010, the name changed to Freightliner AMT^{3™} Automated-Manual Transmission, and new model numbers were applied. See **Table 1** for model numbers.

NOTE: In this workshop manual, the term "AGS transmission" refers collectively to the transmission models in **Table 1**, and the information in this section applies equally to those models.

An AGS transmission gear case holds 9.5 quarts (9.0 liters) of oil. MobilTrans SHC® DC is the approved oil

No clutch pedal is needed to change gears. The clutch is activated by a hydraulic system that also controls the shifting mechanism. After any service, the clutch must be recalibrated.

The hydraulic system is a self-contained AGS unit that attaches to the left-hand side of the gear case. See **Fig. 1**.

The AGS unit has four major components:

- The x-y actuator, which controls the movements of the shift mechanism
- The reservoir, which holds the supply of hydraulic fluid
- The pressure accumulator, which maintains a maximum hydraulic pressure of 1230 psi (8500 kPa)
- The central unit, which controls both electrical and hydraulic inputs

The central unit of the AGS contains the transmission control unit (TCU) and the hydraulic body. On the

rear of the hydraulic body are a hydraulic pump and an electric motor.

The TCU is the electronic center of the AGS. It controls gear changes and monitors the positions of the clutch and the shift mechanism. It receives requests from the shift lever to change drive modes and gears. It broadcasts error messages to the J1587 databus. It communicates to the engine, antilock brakes, and bulkhead module over the J1939 network.

The hydraulic body distributes hydraulic fluid to the clutch, x-y actuator, and accumulator. The hydraulic pump is driven by an electric motor with its own connection to the power distribution module, protected by a 40-amp fuse.

The hydraulic pump comes on automatically when the ignition is turned on, producing a distinctive humming noise that is a characteristic of this transmission. When the noise stops, the hydraulic system is pressurized.

The hydraulic reservoir holds about 1.05 quarts (one liter) of hydraulic fluid. The only fluid used in this system is Pentosin. No other fluid can be substituted.

Both high-pressure and low-pressure hydraulic fittings are not threaded. They can be removed by pressing a brass ring against a soft O-ring and thereby compressing it enough to break the seal and open the line. See **Fig. 2** for the line removal tools.

Certain fasteners used on this transmission contain small amounts of chemical in micro-capsules embedded in the thread. This chemical has sealant and/or thread-locking properties. These fasteners must be replaced at every service for the micro-encapsulated chemical to keep its properties.

IMPORTANT: Do not use Loctite® or sealant on these fasteners.

Transmission Model Numbers				
Mercedes-Benz AGS Freightliner AMT ³ Engine Rating Drive				
MBT520-6DA	AMT3-520-6DA	520 lbf-ft	Direct Drive	
MBT660-6OA	AMT3-660-6OA	660 lbf·ft	Overdrive	

Table 1, Transmission Model Numbers

General Information

Principles of Operation

A shift can be requested either manually, by pushing or pulling the SmartShift lever, or automatically. The AGS judges when to shift automatically through information provided by rotational speed (rpm) sensors. One sensor reads input shaft speed (this sensor is located aft of the central unit, on the countershaft). Two rear sensors read output shaft speed and direction of rotation.

When a shift is requested, hydraulic pressure disengages the clutch. A position sensor attached to the clutch release bearing housing ensures smooth disengagement and engagement.

The x-y actuator moves the shift rod in two dimensions (this is why it is called x-y actuation). With the clutch disengaged, the actuator uses hydraulic pressure to move the shift rod until it is over the correct shift rail. Then it turns the shift rod a precise amount so that the shift finger can engage the shift rail for the correct gear. Two shift position sensors, a gear position sensor and a rail position sensor, assure correct positioning of the shift rod and the shift rail.

From this point on, the mechanism operates in exactly the same way as in any other Mercedes-Benz manual transmission. The notch in the shift rail contacts the shift fork, which moves the synchro slide onto the correct gear wheel.

General Information

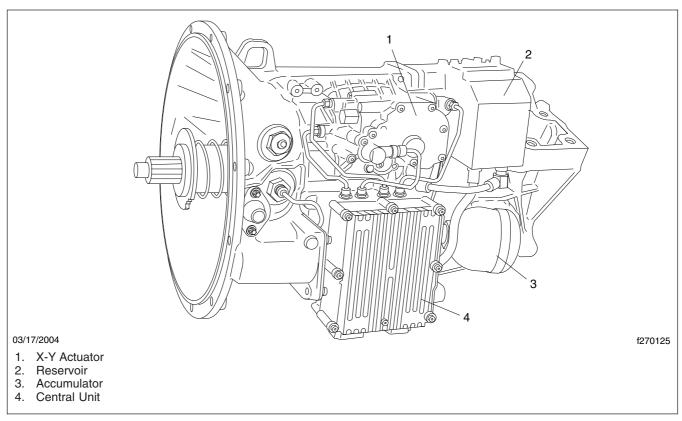


Fig. 1, AGS Unit Components

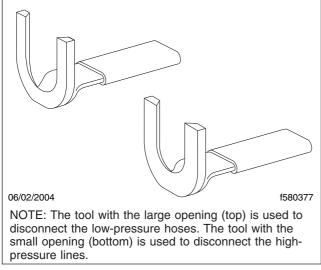


Fig. 2, Hydraulic Fitting Disconnect Tools

Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the rear tires.

IMPORTANT: To prevent loss of hydraulic fluid, depressurize the hydraulic system before removing the transmission.

- 2. Depressurize the hydraulic system. For detailed procedures, see **Subject 160**.
- 3. Disconnect the batteries.
- 4. Disconnect the driveshaft from the transmission. See Fig. 1.

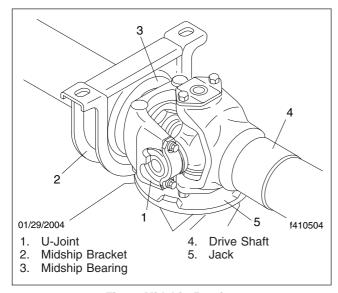


Fig. 1, Midship Bearing

- 4.1 Support the driveline with a jack underneath the aft midship bearing.
- 4.2 Remove the bolts from the aft midship bearing bracket.
- 4.3 Remove the forward midship bracket.
- 4.4 Remove the transmission yoke U-joint from the transmission.
- 4.5 Support the disconnected driveshaft.
- Remove the cab floor plate and cover plate. See Fig. 2.
- 6. Remove all brackets attached to the transmission mounting bolts. Remove all the transmission

- mounting bolts from the bell housing except for the top two. See Fig. 3.
- 7. Remove the two screws attaching the splash guard to the TCU. See Fig. 4.
- Remove the main vehicle harness (X1 connector) and electric motor harness (X3 connector).
 Remove tie straps as necessary. See Fig. 5.
- 9. Support the transmission with a jack. See Fig. 6.
 - 9.1 Position a transmission jack under the transmission and raise its support plates against the base of the transmission.
 - 9.2 Adjust the support plates to cradle the transmission.
 - 9.3 Using a chain, secure the transmission to the jack.
- 10. Remove the top two transmission mounting bolts attaching the timing case to the bell housing.



Do not allow the rear of the transmission to drop, and do not allow the transmission to hang unsupported. Keep the flange of the bell housing parallel (all the way around) to the flange of the timing case, until the input shaft is clear of the flywheel. Taking these precautions will prevent damage to the input shaft, flywheel, and clutch.

- 11. Remove the transmission. See Fig. 7.
 - 11.1 Pull the transmission and jack straight back until the transmission input shaft is clear of the engine.
 - 11.2 If necessary, lower the jack supporting the transmission. It might also be necessary to jack up the truck to get enough clearance to allow the transmission to pass.

IMPORTANT: Watch closely the clearance between the bell housing and the frame rail.

11.3 Pull the transmission out through the space behind the cab.

Installation

IMPORTANT: Before installing the transmission, make sure that the rear tires are chocked and

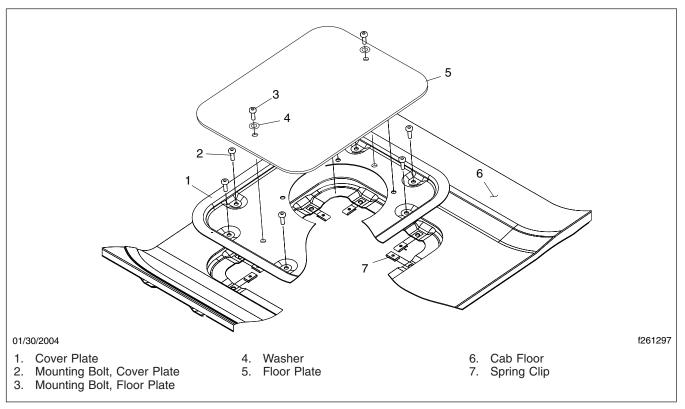


Fig. 2, Floor Access

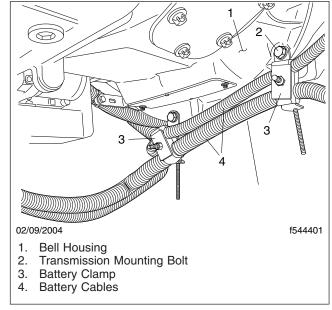


Fig. 3, Battery Cable Brackets

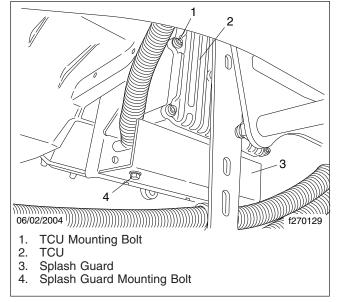


Fig. 4, TCU Splash Guard

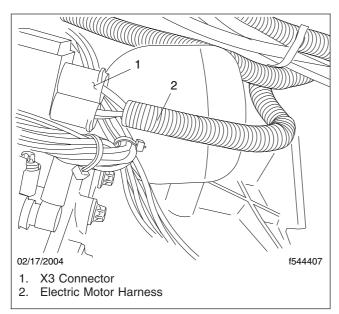


Fig. 5, Harness Connector

that the transmission is securely chained to the support plates on the transmission jack.

- Align the input shaft so that its splines engage the clutch.
 - 1.1 Align the jack and the transmission behind the engine.
 - 1.2 Raise the transmission and adjust the angle of the jack until the bell housing and the timing case flange are parallel.
 - 1.3 Push the transmission and jack straight forward.

NOTE: The AGS transmission automatically selects neutral when shut off. To make sure the clutch and input shaft are properly aligned, this substep requires two persons.

- 1.4 While one person continues to push the transmission forward, the other person uses channel locks or other locking pliers to grip the input shaft and twist it slightly.
- 1.5 When the input shaft and the clutch are aligned, work the transmission further towards the engine and line up the bolt holes in the flywheel housing with those in the bell housing.
- 2. Install the transmission.

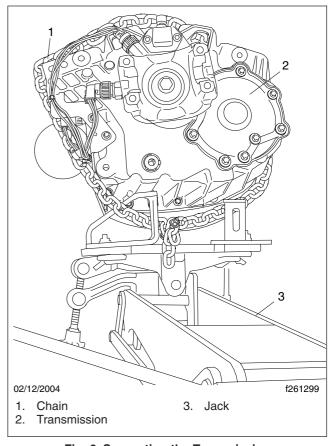


Fig. 6, Supporting the Transmission

- 2.1 Install the M10 transmission mounting bolts holding the bell housing to the timing case. Use a crossover pattern.
- 2.2 While installing the transmission mounting bolts, also install the all the bracket(s) on the bell housing, as removed.
- 2.3 Remove the chain securing the transmission to the jack; then remove the jack.
- 2.4 Do a final tightening of the mounting bolts to 33 lbf·ft (45 N·m).
- 3. Connect the X1 and X3 electrical connectors. Be sure the yellow safety slide on the X1 connector snaps into place.
- Install the cab floor plate and cover plate. See Fig. 2.
- 5. Connect the driveshaft.

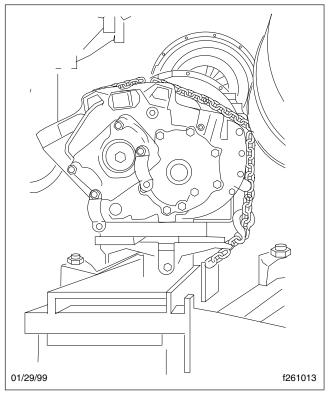


Fig. 7, Remove the Transmission

- 5.1 Slide the front of the driveshaft into the transmission output yoke.
- 5.2 Install the U-joint end caps on the output yoke. Tighten the bolt heads 50 lbf-ft (68 N·m) for 3/8-inch end cap bolts and 110 lbf-ft (149 N·m) for 1/2-inch end cap bolts.
- 5.3 Install the bolts and nuts on the midship bearing brackets. Tighten the nuts 91 lbf·ft (123 N·m).
- Check the hydraulic fluid level and add more Pentosin if needed. See Fig. 8. For detailed procedures, see Subject 150.

IMPORTANT: Use only Pentosin in the hydraulic reservoir. No other fluid can be substituted.

- Connect the batteries.
- Bleed the hydraulic system and recalibrate the transmission according to the procedures in Subject 130.
- Check the transmission fluid level. If low, add transmission fluid until it is level with the lower

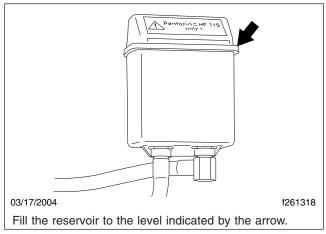


Fig. 8, Hydraulic Fluid Fill Level

edge of the fill opening. See Fig. 9 for the location of the fill plug and Fig. 10 for the correct level. See Group 26 of the Business Class® M2 Maintenance Manual for approved transmission lubricants and lubricant capacities.

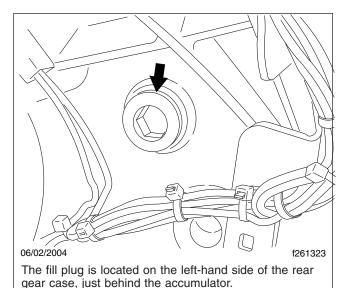


Fig. 9, Fill Plug

- Clean the transmission fill plug and install it on the transmission, along with a new aluminum gasket. Tighten the fill plug 42 lbf·ft (57 N·m).
- 11. Remove the chocks from the rear tires.

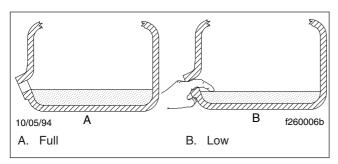


Fig. 10, Transmission Fluid Level Checking

AGS Transmission Control Unit Replacement

IMPORTANT: To successfully replace the transmission control unit (TCU) on the vehicle, there must be at least 2-3/4 inches (70 mm) clearance between the TCU and the frame rail.

Replacement

- Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the rear tires.
- 2. Disconnect the batteries.
- 3. Before starting the replacement procedure, clean all screws and fittings by spraying with a light penetrating oil.
- 4. Remove the two mounting capscrews attaching the splash guard to the TCU. See Fig. 1.

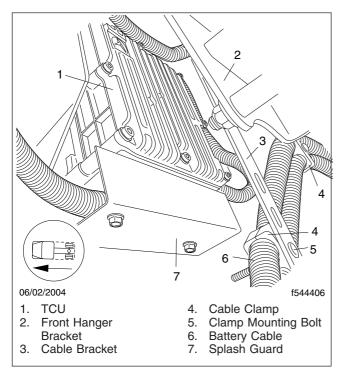
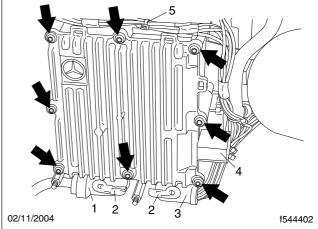


Fig. 1, Area of TCU

Disconnect the X1 (main vehicle), X2 (transmission), and X3 (electric motor) electrical connectors from the base and aft side of the TCU. See Fig. 2. Remove tie straps and clamps as needed.



Remove the eight Torx screws (arrows) attaching the TCU to the hydraulic body.

- 1. X1 (main vehicle) Connector
- 2. Safety Slide
- 3. X2 (transmission) Connector
- 4. X3 (electric motor) Connector
- 5. Tie Strap

Fig. 2, TCU

IMPORTANT: When cutting tie straps at the top of the TCU, use extreme care. Do not cut the wires in the electrical harness.

 Remove the eight Torx® screws attaching the TCU to the hydraulic body. Pull the TCU straight back until all the internal connections are disengaged.

NOTE: Expect some resistance as the internal connections disengage.

- 7. Install the new TCU on the hydraulic body. See Fig. 3.
 - 7.1 Align the new seal ring in the groove provided in the inside of the new TCU.
 - 7.2 Coat the seal ring with enough bearing grease to ensure that the seal ring will not fall out of its groove during installation.
 - 7.3 Make sure all spade connectors are straight.
 - 7.4 Square up the TCU on the hydraulic body using the guide pins on the inside of the TCU. This will ensure that the internal connectors line up properly.

AGS Transmission Control Unit Replacement

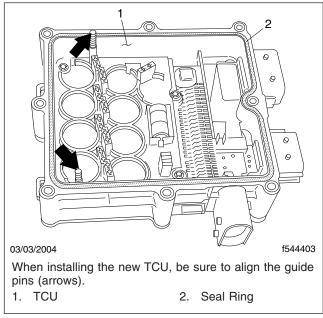


Fig. 3, TCU Seal Ring

7.5 Check that the seal ring does not get pinched along the line where the TCU meets the hydraulic body.

NOTE: Make sure the TCU is seated firmly on the hydraulic body before installing the mounting screws. Do not use the screws to pull the TCU into position.

- 7.6 Install the mounting screws and tighten them 44 to 53 lbf·in (500 to 600 N·cm).
- 8. Attach the electrical connectors. Be sure the yellow slide on the X1 and X2 connector snaps into place. See Fig. 2.
- 9. Replace tie straps and cable clamps as needed.
- 10. Install the splash guard. Tighten the mounting capscrews 17 lbf·ft (23 N·m). See Fig. 1.
- 11. Recalibrate the transmission according to the procedures in **Subject 130**.
- 12. Remove the chocks from the rear tires.

AGS Transmission Sensor Replacement

Replacement

IMPORTANT: Depressurize the hydraulic system before replacing any of the hydraulic components—such as the Clutch Position Sensor, Gear Position Sensor, Rail Position Sensor, and Fluid Level Sensor.

For detailed hydraulic system depressurization procedures, see **Subject 160**. For a diagram of transmission sensors, see **Fig. 1**.

Clutch Position Sensor

The clutch position sensor is integral to the clutch actuator and cannot be replaced without replacing the clutch actuator. For detailed procedures, see **Subject 210**.

Shift Position Sensors

The shift position sensors, shown in **Fig. 2**, are integral to the x-y actuator and cannot be replaced without replacing the x-y actuator. Replacement of the x-y actuator requires removing the transmission from the vehicle. For detailed procedures, see **Subject 170**.

Fluid Level Sensor

- 1. Clean around the area of the reservoir cap. Take care not to introduce dirt into the reservoir.
- If not already done, depressurize the hydraulic system. For detailed procedures, see Subject 160.

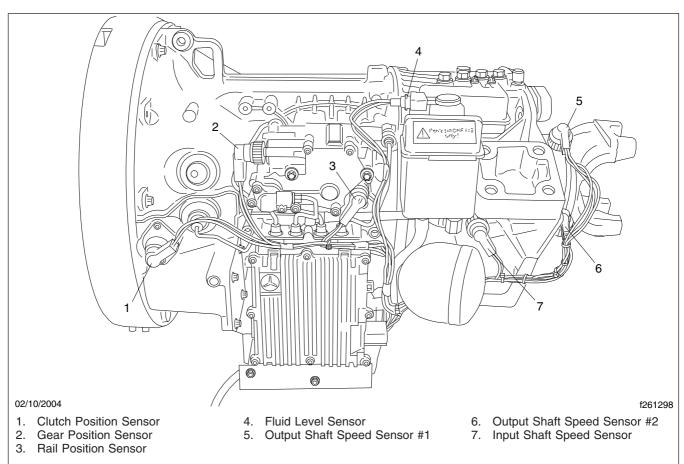


Fig. 1, Transmission Sensors

AGS Transmission Sensor Replacement

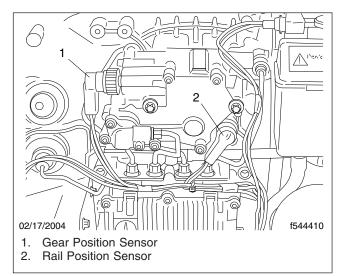


Fig. 2, Shift Position Sensors

3. Remove the electrical connector from the reservoir cap. See **Fig. 3**.

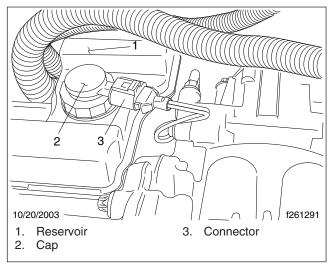


Fig. 3, Fluid Level Sensor

- 3.1 Insert a small screwdriver into the opening at the top of the connector.
- 3.2 Pull back (aft) on the clip until it releases. A click can be heard when it releases.
- 3.3 Remove the connector from the plug on the reservoir cap.
- 4. Unscrew the reservoir cap and remove the cap and probe from the hydraulic reservoir.

- Insert a new cap with probe into the hydraulic reservoir.
- 6. Attach the electrical connector to the new cap and make sure the new cap is tightly fastened.

Speed Sensors

- Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the rear tires.
- Unscrew the electrical connector from the sensor. See Fig. 4 for the input shaft speed sensor and Fig. 5 for the two output shaft speed sensors.

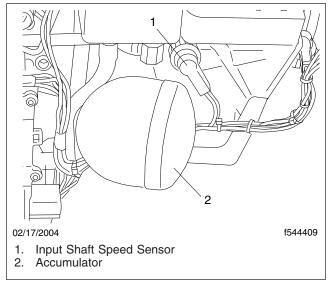


Fig. 4, Input Shaft Speed Sensor

- Using a wrench, remove the sensor from the rear gear case.
- 4. Install a new sensor on the rear gear case. Tighten the sensor 28 lbf-ft (38 N·m).
- 5. Install the electrical connector on the end of the sensor.
- 6. Remove the chocks from the rear tires.

AGS Transmission Sensor Replacement

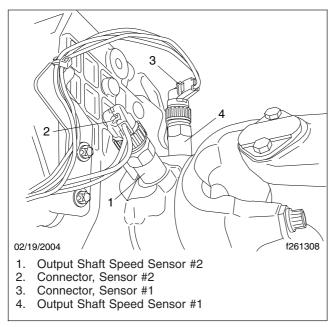


Fig. 5, Output Shaft Speed Sensors

AGS Transmission Bleeding and Recalibration

Bleeding

IMPORTANT: Bleed the hydraulic system after any repair.

 Shut down the engine, set the parking brake, and chock the rear tires.

NOTE: To gain access to the reservoir cap, it may be more convenient to open the floor access plate. See **Subject 100** for procedures.

- Clean around the area of the bleed screw and the reservoir cap. Keep the reservoir cap clean and take care not to introduce dirt into the reservoir.
- 3. With the hydraulic system depressurized (for detailed procedures, see **Subject 160**), remove the plastic cap from the bleed screw. Insert a clear hose onto the bleed valve on the bell housing. Remove the reservoir cap and place the other end of the hose inside the hydraulic reservoir.

IMPORTANT: Do not start the engine.

- 4. Turn on the ignition switch and put the transmission into 1st gear.
- Slowly open the bleed screw. Allow the hydraulic fluid to circulate until no air bubbles are visible and the fluid is clear.
- 6. Tighten the bleed screw 13 lbf·ft (17 N·m).
- Remove the bleed hose and install the reservoir cap.
- 8. Install the plastic cap on the bleed screw.
- 9. Recalibrate the transmission using the procedure under the heading "Recalibration" in this subject.
- Check the hydraulic fluid level and add more Pentosin as needed. See Subject 150 for procedures.

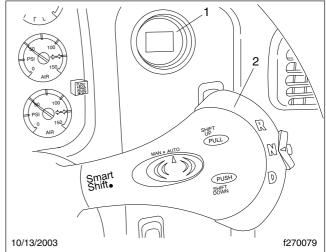
Recalibration

IMPORTANT: Use this procedure when a new transmission is installed, the TCU is replaced, and to correct complaints of rough shifting.

- 1. Shut down the engine and set the parking brake.
- 2. Pressurize the hydraulic pump, as follows.

NOTE: As the hydraulic pump builds pressure, you may hear it humming.

- 2.1 Turn on the ignition, and wait one minute. Then turn off the ignition, and wait one minute. Verify that the current gear indicator is blank.
- 2.2 Again, turn on the ignition, and wait one minute. Then turn off the ignition, and wait one minute. Verify that the current gear indicator is blank.
- Verify that the current gear indicator is blank. Set the selector switch on the SmartShift control to "N" (neutral). See Fig. 1.



Make sure the current gear indicator is blank and the selector switch is set to "N".

- 1. Current Gear Indicator
- 2. SmartShift Control

Fig. 1, Ready to Recalibrate

NOTE: For the recalibration procedure to succeed, the selector switch must remain in neutral until instructed differently later in this procedure.

- With the selector switch in neutral, pull the SmartShift lever up (towards you) and hold it there until instructed to release it later in this procedure
- While holding the SmartShift lever up, turn on the ignition. When the letter "X" displays on the current gear indicator, recalibration is in progress. See Fig. 2. Do not start the engine at this time.

AGS Transmission Bleeding and Recalibration

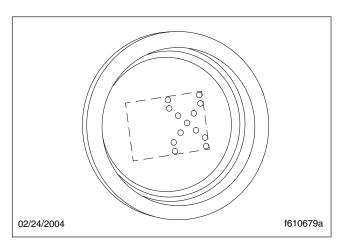


Fig. 2, Recalibration In Progress

NOTE: If the letter "X" does not appear, turn off the ignition, wait one minute, and try again.

6. Wait for the letter "N" to display on the current gear indicator and the audible alert to sound. See Fig. 3. Start the engine within 10 seconds.

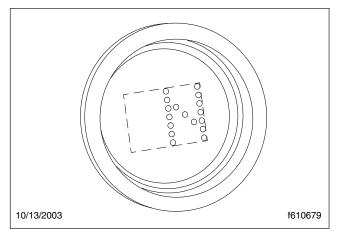


Fig. 3, Neutral Display

- The next time the alert sounds, release the SmartShift lever and shut down the engine. Wait two minutes, turn on the ignition, and do one of the following:
 - If the current gear indicator displays "N", proceed to the next step.
 - If the current gear indicator flashes "SM-N", turn off the ignition and wait two minutes for the display to clear. Then turn on the ignition. If the current gear indicator

- displays "N", proceed to the next step. If it flashes "SM-N", turn off the ignition, wait two minutes or until the display clears, and proceed to the next step.
- If the current gear indicator flashes "SM-X", stop, and repeat the recalibration procedure from the beginning.
- 8. If necessary, turn on the ignition and wait for the letter "N" to display on the current gear indicator. Now select "D" on the SmartShift control, and wait for the numeral "1" to display on the current gear indicator. Then select "R" and wait for "R" to display on the current gear indicator.

IMPORTANT: If the current gear indicator displays "SM" or any other problem occurs, repeat the recalibration procedure from the beginning.

Accumulator Replacement

Special Tool

A special tool is required for this procedure. See Table 1

Special Tool for Accumulator Replacement				
Tool	Description	Description Manufacturer		
f580381	Accumulator Torque Adaptor	Kent-Moore	J-47291	

Table 1, Special Tool for Accumulator Replacement

Replacement

1. Shut down the engine, set the parking brake and chock the rear tires.

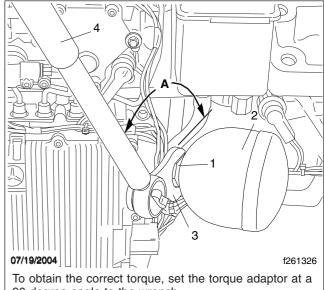
IMPORTANT: Depressurize the hydraulic system before replacing any hydraulic components.

2. Depressurize the hydraulic system. For detailed procedures, see Subject 160.

WARNING

This system is under extremely high pressure. Do not attempt to loosen the accumulator until the system has been depressurized. Hydraulic fluid could spray out at high speed, causing a personal injury.

- 3. Using a socket wrench and the accumulator torque adaptor (Table 1), loosen the M30 fitting on the accumulator.
- 4. Remove the accumulator from the hydraulic body of the AGS central unit.
- 5. Install the accumulator. See Fig. 1.
 - Position the new accumulator on the threaded hole and screw it onto the hydraulic body.
 - 5.2 Assemble the torque wrench and the accumulator torque adaptor (Table 1) with the torque adaptor set at a 90-degree angle to the wrench.



90-degree angle to the wrench.

- A. 90-degree Angle
- 1. Fitting, M30
- 4. Torque Wrench
- Accumulator
- 3. Accumulator Torque Adaptor

Fig. 1, Install the Accumulator

IMPORTANT: If the torque adaptor is not set at a 90-degree angle to the wrench, the M30 fitting will not receive the correct torque.

Accumulator Replacement

- 5.3 Using the torque wrench and adaptor assembly, tighten the M30 fitting 55 lbf-ft (75 N·m).
- 6. Check the hydraulic fluid level and add more Pentosin if needed. For detailed procedures, see **Subject 150**.

IMPORTANT: Use only Pentosin in the hydraulic reservoir. No other fluid can be substituted.

 Start the engine and allow the system to pressurize. Shift back and forth a few times from drive to reverse and back to neutral.

NOTE: The first few shifts after draining and refilling the hydraulic system will take longer than usual.

- 8. Check the hydraulic system for leaks and repair if necessary. When done, shut down the engine.
- 9. Remove the chocks from the rear tires.

Hydraulic Fluid Reservoir Replacement

Special Tool

A special tool is required for this procedure. See **Table 1**.

Special Tool for Hydraulic Fluid Reservoir Replacement				
Tool	Description	Manufacturer Part Numb		
f580379a	Low-Pressure Hose Disconnect Tool	Kent-Moore	J-47202	

Table 1, Special Tool for Hydraulic Fluid Reservoir Replacement

Replacement

 Shut down the engine, set the parking brake and chock the rear tires.

IMPORTANT: Depressurize the hydraulic system before replacing any hydraulic components.

- 2. Depressurize the hydraulic system. For detailed procedures, see **Subject 160**.
- 3. Drain the hydraulic fluid. See Fig. 1.

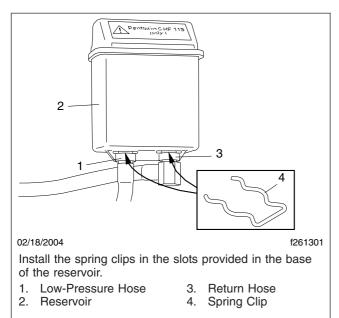


Fig. 1, Hydraulic Hoses

- 3.1 Place a receptacle under the reservoir to catch the drained fluid.
- 3.2 Pull out the spring clips that secure the low-pressure hydraulic hoses to the fittings at the base of the reservoir.
- 3.3 Using the low-pressure hose disconnect tool (Table 1), remove the two lowpressure hydraulic hoses from the reservoir.
- 3.4 Allow the hoses to drain into the container and cap them when fluid no longer drains out.
- 4. Carefully remove the inverted-Torx® M8 fastener at the base of the reservoir. Discard this fastener. See Fig. 2.

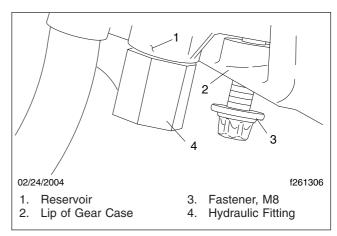


Fig. 2, Fastener, Reservoir Base

Hydraulic Fluid Reservoir Replacement

5. Remove the electrical connector from the reservoir cap. See **Fig. 3**.

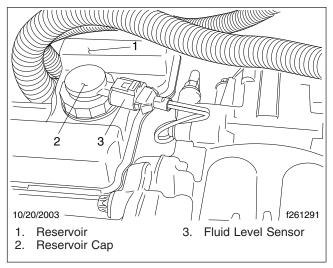


Fig. 3, Reservoir Cap

- 5.1 Insert a small screwdriver into the opening at the top of the connector.
- 5.2 Pull back (aft) on the clip until it releases. A click can be heard when it releases.
- 5.3 Remove the connector from the plug on the reservoir cap.
- 6. Remove the two inverted-Torx M6 fasteners fastening the top of the reservoir to the transmission gear box. See **Fig. 4**.

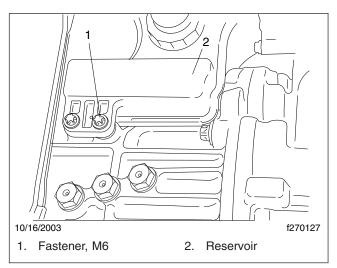


Fig. 4, Fasteners, Reservoir Top

- 7. Remove the reservoir from the transmission.
- 8. Position the new reservoir in the transmission. Install the two M6 fasteners that fasten it to the gear box and tighten them 71 lbf·in (800 N·cm).
- 9. Attach the electrical connector to the reservoir cap. Tug lightly on the connector to make sure it has snapped into place.
- Install a new M8 fastener into the groove at the base of the reservoir. See Fig. 2. Tighten the M8 fastener 11 lbf·ft (18 N·m).

IMPORTANT: Do not use Loctite® or sealant on this fastener.

- 11. Install the low-pressure hydraulic hoses at the base of the reservoir. See **Fig. 1**.
 - 11.1 Install the spring clips in the slots provided.
 - 11.2 Insert the two hydraulic hoses through the spring clips until they snap into place. Tug lightly on the lines to make sure they are securely fastened.

NOTE: After depressurizing, wait five minutes before checking the hydraulic fluid level. This will allow any foam in the fluid to settle.

 Check the hydraulic fluid level. Add Pentosin as needed until the level reaches the joint between the upper and lower sections of the reservoir. See Fig. 5.

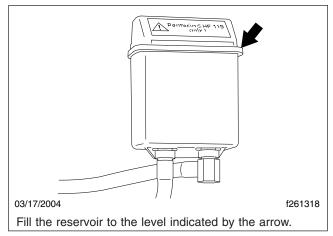


Fig. 5, Hydraulic Fluid Fill Level

IMPORTANT: Use only Pentosin in the hydraulic reservoir. No other fluid can be substituted.

Hydraulic Fluid Reservoir Replacement

13. Start the engine and allow the system to pressurize. Shift back and forth a few times from drive to reverse and back to neutral.

NOTE: The first few shifts after draining and refilling the hydraulic system will take longer than usual.

- 14. Check the hydraulic system for leaks and repair if necessary. When done, shut down the engine.
- 15. Remove the chocks from the tires.

AGS Hydraulic System Depressurization

IMPORTANT: Depressurize the hydraulic system before removing the transmission or replacing any hydraulic components.

Depressurization

Normal Procedure

- 1. Shut down the engine and set the parking brake.
- 2. Connect ServiceLink to the vehicle. Start the "AGS Procedures" template and follow the instructions on the screen to depressurize the system. See Fig. 1.
 - 2.1 Press the "Start Communications" button.
 - 2.2 Select "Start Diagnostic Mode."
 - 2.3 Select the "Reduce Hyd Pressure" button to depressurize the system.
- 3. Turn off the ignition switch. Wait for the system to depressurize. When the system depressurizes, the accumulator will dump its fluid into the reservoir, causing an obvious rise in the reservoir level.

IMPORTANT: If the reservoir level fails to rise, or any other problem prevents the system from depressurizing, use the alternate procedure. Do not use the alternate procedure unless the normal procedure fails.

4. Disconnect ServiceLink from the vehicle.

Alternate Procedure

NOTE: The pressure-limiting valve is designed to be opened a limited number of times. Do not use it routinely to depressurize the system.

 Open the pressure-limiting valve embedded in the forward side of the x-y actuator. Loosen the M6 adjusting screw carefully one quarter-turn. See Fig. 2.

IMPORTANT: Do not loosen the adjusting screw more than one quarter-turn. If the pressurelimiting valve is opened wider than that, it can cause the accumulator to discharge.

2. Close the M6 adjusting screw when depressurization is complete. Tighten it 62 to 71 lbf·in (700 to 800 N·cm).

AGS Hydraulic System Depressurization

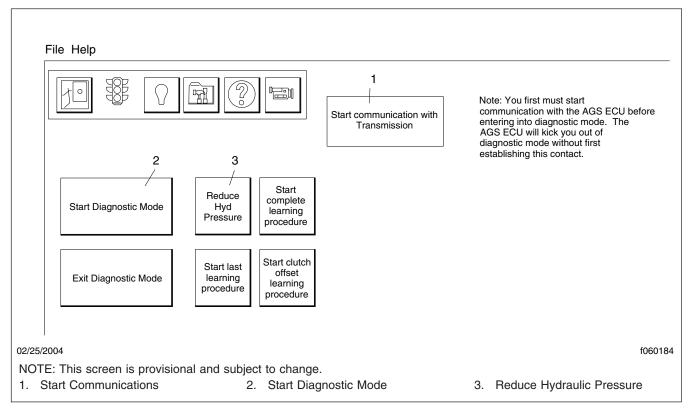


Fig. 1, ServiceLink Depressurization Screen

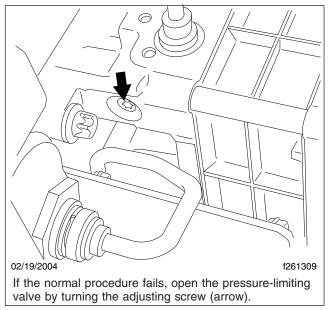


Fig. 2, Alternate Procedure

X-Y Actuator Replacement

Special Tool

A special tool is required for this procedure. See **Table 1**.

Special Tool for X-Y Actuator Replacement				
Tool	Description	Manufacturer	Part Number	
1580379	High-Pressure Line Disconnect Tool	Kent-Moore	J-47201	

Table 1, Special Tool for X-Y Actuator Replacement

Replacement

 Shut down the engine, set the parking brake and chock the rear tires.

NOTE: Replacement of the x-y actuator requires removing the transmission from the vehicle.

2. Remove the transmission from the vehicle. For detailed procedures, see **Subject 100**.

IMPORTANT: Depressurize the hydraulic system before replacing any hydraulic components.

- If not already done, depressurize the hydraulic system. For detailed procedures, see Subject 160.
- Remove the AGS assembly from the transmission. For detailed procedures, see Subject 200.
- 5. Before starting the replacement procedure, clean all screws and fittings by spraying with a light penetrating oil.
- 6. Using the high-pressure hydraulic line disconnect tool (**Table 1**), remove the high-pressure hydraulic lines from the actuator. See **Fig. 1**.
 - 6.1 Mark each line and attachment point with a paint pen for ease of installation.
 - 6.2 Place the high-pressure line tool in front of the metal ring. Use the tool to pull on the line and shake it slightly until the line comes free.

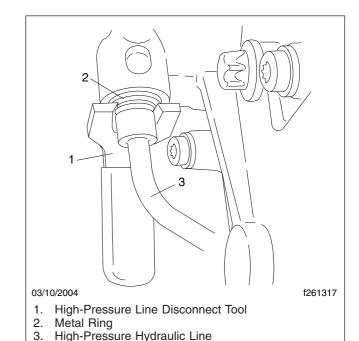


Fig. 1, Removing the High-Pressure Hydraulic Lines

6.3 Carefully pull the line away from the attachment point and pull it free of the actuator.



Be careful not to bend or damage the lines or the O-rings when removing them.

X-Y Actuator Replacement

NOTE: Make sure the actuator is seated firmly on the mounting flange. Do not use the mounting capscrews to pull the actuator into position.

 Install the four M8 mounting capscrews fingertight in the actuator. Make sure they are firm all around. Then tighten them 17 lbf-ft (23 N·m).

A CAUTION -

Do not twist or bend the hydraulic lines. This will make installation more difficult and could damage the lines.

8. Install the hydraulic lines in the actuator, as removed. See Fig. 2.

- 8.1 The lines snap into place with an audible click. When the installation is correct, the outermost O-ring is no longer visible. See Fig. 3.
- 8.2 Tug lightly on each line to make sure it is locked in place.
- Install the connectors for the two position sensors on the actuator.
- 10. Install the AGS assembly on the transmission. For detailed procedures, see **Subject 200**.
- 11. Install the transmission on the vehicle. For detailed procedures, see **Subject 100**.

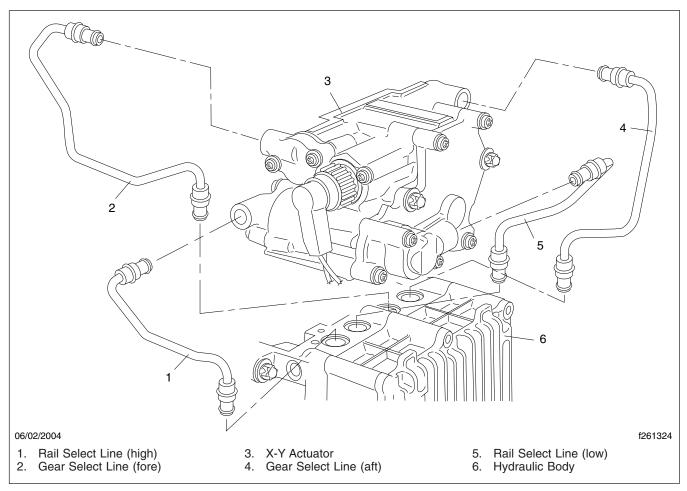


Fig. 2, Install the Hydraulic Lines

X-Y Actuator Replacement

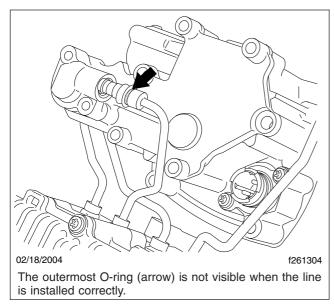


Fig. 3, Snap the Lines Into Place

 Start the engine and allow the system to pressurize. Shift back and forth a few times from drive to reverse and back to neutral.

NOTE: The first few shifts after draining and refilling the hydraulic system will take longer than usual.

- 13. Check the hydraulic system for leaks and repair if necessary. When done, shut down the engine.
- 14. Check the hydraulic fluid level and add more Pentosin as needed. For detailed procedures, see **Subject 150**.

IMPORTANT: Use only Pentosin in the hydraulic reservoir. No other fluid can be substituted.

15. Remove the chocks from the rear tires.

AGS Transmission Harness Replacement

Replacement

NOTE: This procedure can be done with the transmission either installed on, or removed from, the vehicle.

- 1. Disconnect the batteries.
- 2. Remove the two mounting capscrews that attach the splash guard to the TCU. See **Fig. 1**.

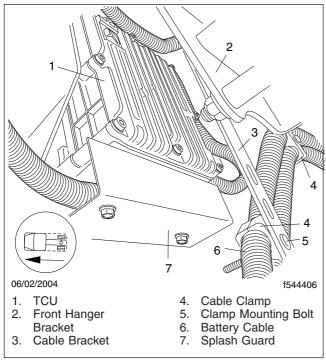


Fig. 1, Area of TCU

- 3. Remove the X2 (transmission) connector from the transmission control unit (TCU).
- 4. Unscrew the electrical connector cap from the clutch position sensor plug on the bell housing. See Fig. 2. Mark the cap of the connector and the plug with a paint pen.
- 5. Remove the electrical connector from the reservoir cap.
 - 5.1 Insert a small screwdriver into the opening at the top of the connector.
 - 5.2 Pull back (aft) on the clip until it releases. A click can be heard when it releases.

- 5.3 Remove the connector from the plug on the reservoir cap.
- 6. Unscrew the electrical connectors from the gear and rail position sensors on the x-y actuator. Mark the cap and plug of each connector with a paint pen.
- Unscrew the electrical connector from the input shaft speed sensor on the left-hand side of the rear gear case just aft of the accumulator. Mark the cap and plug of the connector with a paint pen.
- Unscrew the electrical connectors from the two output shaft speed sensors on the aft end of the rear gear case. Mark the cap and plug of each connector with a paint pen.
- 9. Cut tie straps as needed to remove the harness from the transmission.

IMPORTANT: Be careful to color-code each connector. If the connectors are not installed in the correct locations, the transmission will not operate properly.

- 10. Lay the old harness next to the new harness on a table. Match up each connector on the new harness with the corresponding connector on the old harness. Use paint pens to mark each connector on the new harness with the color of its corresponding connector on the old harness.
- 11. Install the X2 (transmission) connector on the aft side of the TCU. Make sure the yellow safety slide snaps into place.
- 12. Install the two mounting capscrews that attach the splash guard to the TCU.
- 13. Install the new harness, matching each connector by color. Install new tie straps as needed.
- 14. Connect the batteries. Start the engine and check the electrical system for proper operation.

AGS Transmission Harness Replacement

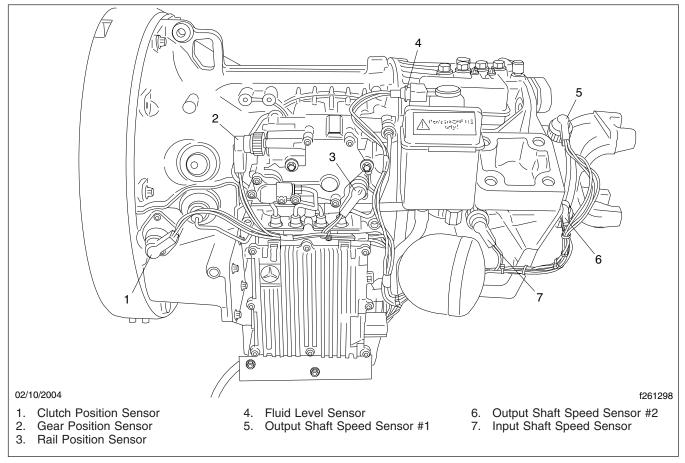


Fig. 2, Transmission Sensors

AGS Central Unit Replacement

Special Tool

A special tool is required for this procedure. See **Table 1**.

Special Tool for X-Y Actuator Replacement				
Tool	Description	Manufacturer	Part Number	
f58037t	High-Pressure Line Disconnect Tool	Kent-Moore	J-47201	

Table 1, Special Tool for X-Y Actuator Replacement

Replacement

 Shut down the engine, set the parking brake and chock the rear tires.

NOTE: Replacement of the x-y actuator requires removing the transmission from the vehicle.

2. Remove the transmission from the vehicle. For detailed procedures, see **Subject 100**.

IMPORTANT: Depressurize the hydraulic system before replacing any hydraulic components.

- If not already done, depressurize the hydraulic system. For detailed procedures, see Subject 160.
- Remove the AGS assembly from the transmission. For detailed procedures, see Subject 200.



Make sure the AGS assembly is well supported before working on the hydraulic lines. If necessary, call another person to help support it. The weight of the assembly components could cause damage to the lines.

- Before starting the replacement procedure, clean all screws and fittings by spraying with a light penetrating oil.
- 6. Using the high-pressure hydraulic line disconnect tool (**Table 1**), remove the four high-pressure hydraulic lines from the x-y actuator. For procedures, see **Subject 170**.



Be careful not to bend or damage the lines or the O-rings when removing them.

NOTE: The central unit has two parts: in front is the transmission control unit (TCU), and behind it is the hydraulic body.

7. Still using the high-pressure hydraulic line disconnect tool, remove the high-pressure hydraulic lines from the central unit. See Fig. 1.

NOTE: There are five lines that connect to the hydraulic body of the central unit. One line connects to the clutch and four lines connect to the x-y actuator.

7.1 Mark each line and attachment point with a paint pen for ease of installation. On the top of the hydraulic body, remove the outer lines first.

IMPORTANT: Don't use the tool as a lever. Work it in until it is fully engaged and then wiggle until the line comes free.

- 7.2 Place the high-pressure line tool in front of the metal ring. Press down to compress the locking device, and then pull outward and shake the tool slightly until the line comes free.
- 7.3 Once all the lines are unlocked, carefully separate the central unit from the rest of the AGS assembly.

AGS Central Unit Replacement

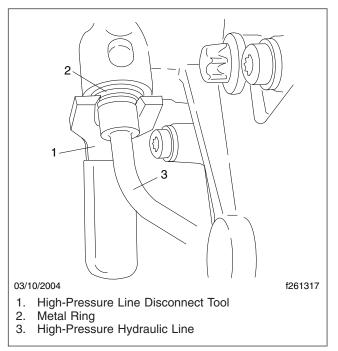


Fig. 1, Using the High-Pressure Line Disconnect Tool



Do not twist or bend the hydraulic lines. This will make installation more difficult and could damage the lines.

- 8. Install the hydraulic lines in the central unit, as removed. See Fig. 2.
 - 8.1 The lines snap into place with an audible click. When the installation is correct, the outermost O-ring is no longer visible. See Fig. 3.
 - 8.2 Tug lightly on each line to make sure it is locked in place.
- Install the high-pressure hydraulic lines on the x-y actuator, as removed. For procedures, see Subject 170.
- 10. Install the AGS assembly on the transmission. For detailed procedures, see **Subject 200**.
- 11. Install the transmission on the vehicle. For detailed procedures, see **Subject 100**.
- 12. Start the engine and allow the system to pressurize. Shift back and forth a few times from drive to reverse and back to neutral.

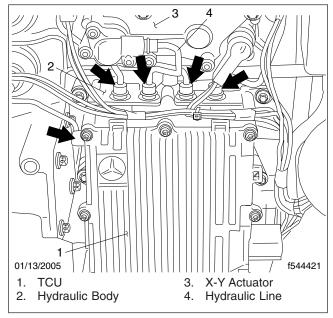


Fig. 2, Hydraulic Lines on the Central Unit

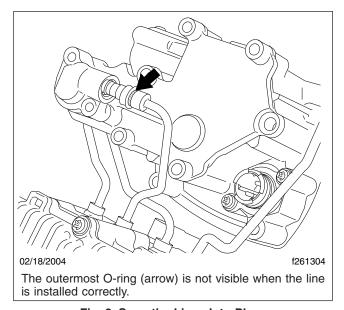


Fig. 3, Snap the Lines Into Place

NOTE: The first few shifts after draining and refilling the hydraulic system will take longer than usual.

13. Check the hydraulic system for leaks and repair if necessary. When done, shut down the engine.

Freightliner AMT³ and Mercedes-Benz Automated-Manual Transmissions

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AGS Central Unit Replacement

14. Check the hydraulic fluid level and add more Pentosin as needed. For detailed procedures, see **Subject 150**.

IMPORTANT: Use only Pentosin in the hydraulic reservoir. No other fluid can be substituted.

15. Remove the chocks from the rear tires.

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools for AGS Assembly Installation				
Tool	Description	Manufacturer	Part Number	
1580380	Shift Finger Alignment Fork	Kent-Moore	J-47204	
1580382	Shift Mechanism End Guide	Kent-Moore	J-47203	

Table 1, Special Tools for AGS Assembly Installation

Removal

1. Shut down the engine, set the parking brake and chock the rear tires.

NOTE: Replacement of the AGS assembly requires removing the transmission from the vehicle.

Remove the transmission from the vehicle. For detailed procedures, see Subject 100.

IMPORTANT: Depressurize the hydraulic system before replacing any hydraulic components.

- If not already done, depressurize the hydraulic system. For detailed procedures, see Subject 160.
- Remove the two mounting capscrews attaching the splash guard to the transmission control unit (TCU). See Subject 110 for instructions.
- Disconnect the X1 (main vehicle) and X3 (electric motor) electrical connectors from the base and aft side of the TCU. Mark both the cap and plug of the connector with a paint pen for ease of installation. Remove tie straps and clamps as needed.

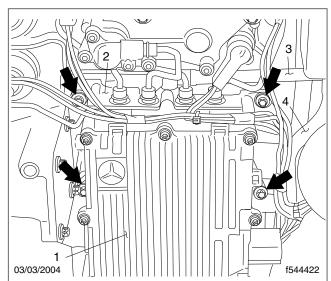
- Remove the electrical connectors from the clutch position sensor at the bell housing, and from the three speed sensors on the rear gear case. Mark both the cap and plug of the connector with a paint pen for ease of installation.
- Remove the high-pressure clutch hydraulic line from the bell housing. For procedures, see Subject 120.
- 8. Remove the accumulator. For detailed procedures, see **Subject 140**.
- Remove the hydraulic fluid reservoir. For detailed procedures, see Subject 150.

NOTE: The central unit has two parts: in front is the TCU and behind it is the hydraulic body.

- Remove the four inverted-Torx® capscrews that attach the central unit to the transmission. See Fig. 1. See Fig. 2.
- 11. Remove the four inverted-Torx capscrews that attach the x-y actuator to the transmission. See Fig. 2.

NOTE: The two upper capscrews are 110 mm long; the two lower capscrews are 60 mm long.

12. Remove the x-y actuator assembly from the front gear case.



Remove the four inverted-Torx capscrews (arrows) that attach the central unit to the transmission.

- 1. Transmission Control Unit (TCU)
- 2. Hydraulic Body
- 3. Low-Pressure Return Hose
- 4. Low-Pressure Supply Hose

Fig. 1, AGS Central Unit Mounting Capscrews

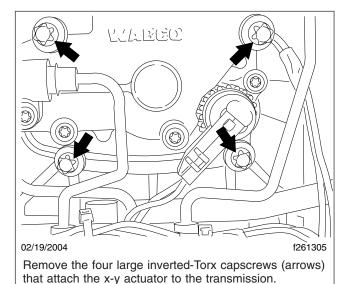


Fig. 2, X-Y Actuator Mounting Capscrews

12.1 From the right-hand side of the transmission, remove the setscrew that holds the end of the shift rod.

12.2 Remove the sheet metal shift cover at the end of the shift cover housing. See Fig. 3. Tap the shift cover with a drift to dislodge it, and then pull it out of the shift cover housing with pliers. Discard this shift cover.

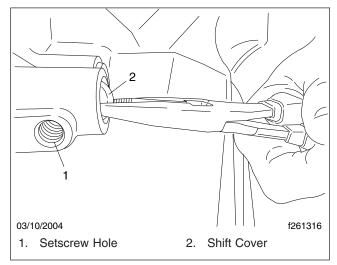


Fig. 3, Removing the Shift Cover

12.3 Pull the actuator assembly, complete with the shift rod, out of the front gear case.

IMPORTANT: If there is difficulty in separating the x-y actuator from the gear case, install the shift mechanism end guide on the end of the shift rod. Then use a rubber mallet to pound gently on the end guide until the actuator comes free.

- Carefully remove the entire AGS assembly from the transmission.
- 14. If necessary due to wear, file around the setscrew bore at the end of the shift rod. When finished filing, be sure to remove any metal scraps, shavings, or other residue.

Installation

 Using the shift finger alignment fork (Table 1), align the shift finger. See Fig. 4. Leave the fork in place until the shift rod is installed in the front gear case. Screw the shift mechanism end guide (Table 1) onto the shift rod.

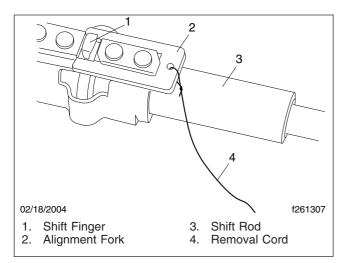


Fig. 4, Align the Shift Finger

NOTE: Turn the shift rod to make sure the countersunk bore for the setscrew is rotated at a 90-degree angle away from the shift finger.

- Install the actuator assembly in the front gear case.
 - 2.1 Clean the mating surface between the actuator assembly and the front gear case. Coat the mating surface with Loctite® 509 or equivalent sealing compound.
 - 2.2 Insert the actuator assembly into the front gear case. Make sure that the removal cord attached to the end of the alignment fork is accessible.

NOTE: For ease of entry, it helps to tip the shift fork slightly downwards and to the rear.

- 2.3 When the shift rod is in far enough to engage the shift finger, there will be about a two-inch (50-mm) gap between the back of the x-y actuator and the mating surface on the front gear case. Use the removal cord to pull out the alignment fork.
- 2.4 Set the x-y actuator against the mating surface. If necessary, turn the shift rod in a clockwise direction until the setscrew bore is visible through the hole provided.
- 2.5 Install the M12 setscrew in the countersunk bore in the shift rod, but do not tighten it yet. See **Fig. 5**.

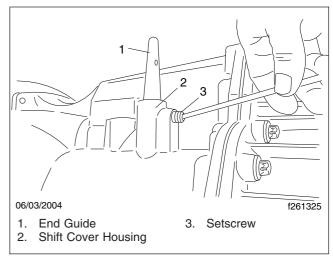


Fig. 5, Install the Setscrew

- 2.6 When the shift rod is all the way in, unscrew the end guide.
- 2.7 Turn the shift rod until the indent on the end of the shift rod is at the 9 o'clock position. See **Fig. 6**.

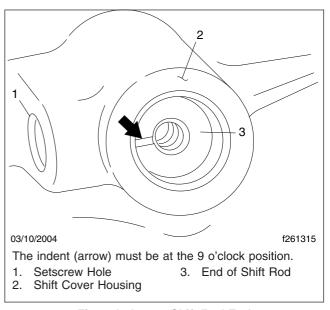


Fig. 6, Indent at Shift Rod End

2.8 Before tightening, make sure the setscrew is firmly seated in the shift rod. Tighten the setscrew 22 lbf·ft (30 N·m).

- 2.9 Press a new shift cover onto the shift cover housing.
- Install the hydraulic fluid reservoir. For detailed procedures, see Subject 150.
- Install the accumulator. For detailed procedures, see Subject 140.
- Install the high-pressure clutch hydraulic line, as removed.
- Coat the threads of the four inverted-Torx actuator mounting capscrews with Loctite 509 or equivalent thread-locking compound. Install the four capscrews on the x-y actuator and tighten them 17 lbf·ft (23 N·m).
- Coat the threads of the four inverted-Torx central unit mounting capscrews with Loctite 509 or equivalent thread-locking compound. Install the four capscrews on the central unit and tighten them 17 lbf·ft (23 N·m).
- Connect all the electrical connectors, as removed.
- Bleed the hydraulic system. For procedures, see Subject 130.
- Add Pentosin as needed until the level reaches the joint between the upper and lower sections of the reservoir. For detailed procedures, see Subject 150.

IMPORTANT: Use only Pentosin in the hydraulic reservoir. No other fluid can be substituted.

- Install the splash guard before installing the transmission. Tighten the mounting screws 17 lbf·ft (23 N·m). See Subject 110 for instructions.
- Install the transmission on the vehicle. For detailed procedures, see Subject 100.
- Start the engine and allow the system to pressurize. Shift back and forth a few times from drive to reverse and back to neutral.

NOTE: The first few shifts after draining and refilling the hydraulic system will take longer than usual.

- Check the hydraulic fluid level and add more Pentosin as needed. For detailed procedures, see Subject 150.
- 15. Check the hydraulic system for leaks and repair if necessary. When done, shut down the engine.
- 16. Remove the chocks from the rear tires.

Clutch Actuator Replacement

Replacement

NOTE: Replacement of the clutch actuator requires removing the transmission from the vehicle.

- 1. Remove the transmission from the vehicle. For detailed procedures, see **Subject 100**.
- If not already done, depressurize the hydraulic system. For detailed procedures, see Subject 160.
- Unlock the electrical connector cap from the clutch position sensor. See Fig. 1. Turn the lock collar on the connector plug 90 degrees counterclockwise and remove it. Then remove the connector plug and the position sensor wire from the bell housing.

- 4. Loosen the clutch actuator mounting capscrews, but do not remove them yet.
- 5. Lift up the spring clip from the hydraulic line and carefully pull the hydraulic line straight out, using a minimum of force. See Fig. 2.
- Remove the clutch actuator (release bearing housing and concentric slave cylinder). See Fig. 3.
 - 6.1 Remove both 30-mm hexhead hydraulic fittings from the bell housing.
 - 6.2 Remove the clutch actuator mounting capscrews that attach the clutch actuator to the bell housing.
 - 6.3 Slide the clutch actuator off the transmission input shaft.

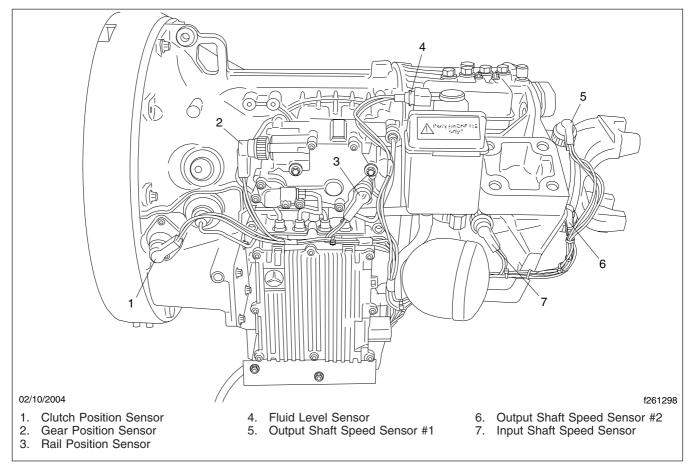
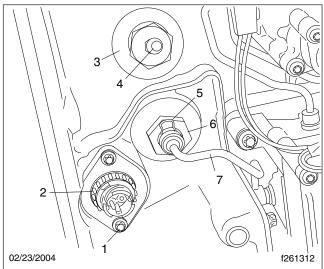


Fig. 1, Transmission Sensors

Clutch Actuator Replacement



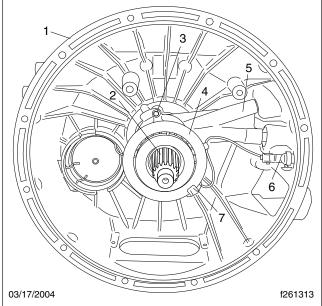
- 1. Mounting Plate Capscrew
- 2. Connector Plug
- 3. 30-mm Hexhead Hydraulic Bleed Fitting
- Bleed Screw
- 5. Spring Clip
- 6. 30-mm Hexhead Hydraulic Pressure Fitting
- 7. Hydraulic Line

Fig. 2, Clutch Components on Bell Housing

- 7. Slide the clutch actuator onto the input shaft. Install the clutch actuator on the bell housing.
 - 7.1 Install new clutch actuator mounting capscrews and tighten 17 lbf-ft (23 N·m).

IMPORTANT: Do not use Loctite® or sealant on these fasteners.

- 7.2 Connect the hydraulic line and the fitting that attaches it to the bell housing. Make sure the spring clip engages properly.
- 7.3 Install the bleed screw and the fitting that attaches it to the bell housing.
- 7.4 Attach the sensor wire, connector, and connector plug assembly to the bell housing. Lock the electrical connector cap onto the connector plug.
- 7.5 Tighten all hydraulic fittings 37 lbf·ft (50 N·m).
- Install the transmission in the vehicle. For detailed procedures, see Subject 100.



- 1. Lip of Bell Housing
- 2. Input Shaft
- 3. Clutch Actuator Mounting Capscrew
- 4. Release Bearing Housing
- 5. Concentric Slave Cylinder
- 6. Position Sensor Connector
- Clutch Position Sensor

Fig. 3, Clutch Actuator

General Troubleshooting

IMPORTANT: Always use ServiceLink when attempting to diagnose problems with the AGS (Automated Gear Shift) transmission.

How To Start

To gain a baseline for troubleshooting when there is no definite problem, when the malfunction is erratic or intermittent, or to determine the general health of the electrical system, start with the electrical pre-test in **Subject 301**.

In a few cases there will be a definite problem and no J1587 fault code will be sent (engine will not crank, no information on gear display, fluid level fault). For these problems, see the appropriate table in **Subject 301**.

But in most cases, the J1587 fault code is the starting point for the troubleshooting procedures. See **Table 1** to find information for SID fault codes. See **Table 2** to find information for PID fault codes.

Before starting any procedures, use ServiceLink to depressurize the AGS hydraulic system. For detailed procedures, see **Subject 160**.

Fault Code Guide

To troubleshoot a given fault code, look up the subject number in **Table 1** (for SIDs) and **Table 2** (for PIDs). Follow the procedures for that fault code until the fault is corrected.

	Fault Code Guide (MID 130 SIDs)				
SID	FMI	Text Message	Failure Reason	Procedure	
18	02	Prim Selector Erratic	The shift lever does not shift gears.	See Subject 302.	
33	03	MultiPress Ind Short Hi	The hydraulic pressure sensor circuit is shorted to power.	See Subject 303.	
33	04	MultiPress Ind Short Lo	The hydraulic pressure sensor circuit is shorted to ground.	See Subject 303.	
33	05	MultiPress Ind OPEN	The hydraulic pressure sensor circuit is open.	See Subject 303.	
52	05	Hydraulic Sys OPEN	The hydraulic pump circuit is open.	See Subject 304.	
52	07	Hydraulic Sys NoRESPONSE	The hydraulic pressure does not increase even though the hydraulic pump is activated.	See Subject 304.	
52	11	Clutch Act Not Known	The hydraulic pump temperature is too high.	See Subject 304.	
55	00	Clutch Act HIGH	The clutch is too hot.	See Subject 305.	
55	07	Clutch Act NoRESPONSE	The clutch does not operate properly.	See Subject 305.	
55	13	Clutch Act Calibrate	The clutch needs to be calibrated.	See Subject 305.	
231	02	SAE J1939 Datalink Erratic	The J1939 datalink is not communicating properly.	See Subject 306.	
231	09	SAE J1939 Datalink UPDATE	The J1939 datalink has timed out.	See Subject 306.	
231	12	SAE J1939 Datalink Bad	The J1939 datalink is not communicating with the transmission.	See Subject 306.	
251	00	POWER SUPPLY HIGH	The power supply voltage is too high.	See Subject 307.	
251	01	POWER SUPPLY Low	The power supply voltage is too low.	See Subject 307.	
251	05	POWER SUPPLY OPEN	There is no power to the transmission with the engine running.	See Subject 307.	
251	14	POWER SUPPLY RSRVD	The power supply is not properly grounded.	See Subject 307.	
253	02	Calibration Memory Erratic	The transmission needs to be recalibrated.	See Subject 308.	
253	12	Calibration Memory Bad	The transmission needs to be recalibrated.	See Subject 308.	
253	13	Calibration Memory Calibrate	The transmission needs to be recalibrated.	See Subject 308.	
253	14	Calibration Memory RSRVD	The transmission needs to be recalibrated.	See Subject 308.	

General Troubleshooting

	Fault Code Guide (MID 130 SIDs)				
SID	SID FMI Text Message Failure Reason		Procedure		
254	04	Controller Short Lo	The TCU is shorted to ground.	See Subject 309.	
254	05	Controller OPEN	The TCU has an open circuit.	See Subject 309.	
254	11	Controller Not Known	The TCU AUTO mode software module has an error.	See Subject 309.	
254	12	Controller Bad	The TCU has a hardware problem.	See Subject 309.	
254	13	Controller Calibrate	The TCU has a software memory problem.	See Subject 309.	

Table 1, Fault Code Guide (SIDs)

	Fault Code Guide (MID 130 PIDs)			
PID	FMI	Text Message	Failure Reason	Procedure
33	02	Erratic	The clutch position sensor gives invalid data.	See Subject 310.
33	03	Short Hi	The clutch position sensor circuit is shorted to power.	See Subject 310.
33	04	Short Lo	The clutch position sensor circuit is shorted to ground.	See Subject 310.
33	05	OPEN	The clutch position sensor circuit is open.	See Subject 310.
33	14	RSRVD	The clutch position sensor gives incorrect resistance readings.	See Subject 310.
59	02	Shift FNGR Gear Erratic	The shift rod position sensor gives invalid data.	See Subject 311.
59	03	Shift FNGR Gear Short Hi	The gear position sensor circuit is shorted to power.	See Subject 311.
59	04	Shift FNGR Gear Short Lo	The gear position sensor circuit is shorted to ground.	See Subject 311.
59	05	Shift FNGR Gear OPEN	The gear position sensor circuit is open.	See Subject 311.
59	14	Shift FNGR Gear RSRVD	The gear position sensor gives incorrect resistance readings.	See Subject 311.
60	02	Shift FNGR Rail Erratic	The rail position sensor circuit gives invalid data.	See Subject 312.
60	03	Shift FNGR Rail Short Hi	The rail position sensor circuit is shorted to power.	See Subject 312.
60	04	Shift FNGR Rail Short Lo	The rail position sensor circuit is shorted to ground.	See Subject 312.
60	05	Shift FNGR Rail OPEN	The rail position sensor circuit is open.	See Subject 312.
60	14	Shift FNGR Rail RSRVD	The rail position sensor gives incorrect resistance readings.	See Subject 312.
64	09	Dir Switch Update	The output shaft speed sensor is not providing accurate directional information.	See Subject 313.
64	11	Dir Switch Not Known	The output shaft speed sensor is not providing accurate directional information.	See Subject 313.
158	00	Volts (BattSw) HIGH	The voltage in the ignition power circuit is too high.	See Subject 314.
158	01	Volts (BattSw) Low	The voltage in the ignition power circuit is too low.	See Subject 314.
161	02	In shaft SPEED Erratic	The input shaft speed sensor circuit gives invalid data.	See Subject 315.
161	03	In shaft SPEED Short Hi	The input shaft speed sensor circuit is shorted to power.	See Subject 315.
161	04	In shaft SPEED Short Lo	The input shaft speed sensor circuit is shorted to ground.	See Subject 315.
161	05	In shaft SPEED OPEN	The input shaft speed sensor circuit is open.	See Subject 315.
161	08	In shaft SPEED Update	The input shaft speed sensor circuit is broadcasting an abnormal frequency.	See Subject 315.

General Troubleshooting

	Fault Code Guide (MID 130 PIDs)				
PID	PID FMI Text Message Failure Reason		Procedure		
162	02	RANGE Selected Erratic	The transmission is not properly calibrated.	See Subject 316.	
163	02	RANGE Attained Erratic	The gears do not shift properly.	See Subject 316.	
191	02	OUTPUT SPEED Erratic	One or both of the output shaft speed sensor circuits give invalid data.	See Subject 317.	
191	05	OUTPUT SPEED OPEN	One or both of the output shaft speed sensor circuits are open.	See Subject 317.	
191	08	OUTPUT SPEED SIGNAL	There is no signal coming from one or both output shaft speed sensors.	See Subject 317.	
191	14	OUTPUT SPEED RSRVD	The output shaft speed sensor is providing invalid data.	See Subject 317.	

Table 2, Fault Code Guide (PIDs)

IMPORTANT: Always use ServiceLink when attempting to diagnose problems with the automated gear shift (AGS) transmission.

In most cases, the J1587 fault code is the starting point for the troubleshooting procedures. See **Subject 300** for a list of fault codes and the location of troubleshooting procedures for each code.

Use the electrical pre-test instructions given in **Table 1** as a baseline for troubleshooting when there is no definite problem, the malfunction is erratic or intermittent, or as an informational step to determine the general health of the electrical system. To record your findings, a result sheet is provided at the end of this subject. For locations of serial numbers, see **Fig. 1** and **Fig. 2**.

Electrical Pre-Test Instructions

Before starting any procedures, use ServiceLink to depressurize the AGS hydraulic system. For detailed procedures, see **Subject 160**.

	Electrical Pre-Test			
Procedure	Result	Action		
Make sure that the selector switch on the SmartShift lever is set to N. Turn on the ignition switch to power up the	The current gear indicator does not power up normally. No fault codes display.	Troubleshoot the current gear indicator. See Table 4 .		
transmission. NOTE: If the hydraulic pump starts up with its characteristic humming noise, this means the main power cables are OK (see the steps below to check the X3 connector).	The current gear indicator goes through its normal power-up sequence, ending by displaying "N."	Turn off the ignition switch and go to the next row in the table.		
With the ignition switch off, check the voltage at the battery.	Voltage is less than 11 or greater than 13 volts.	Charge or replace the battery. For battery charging procedures, see Section 54.12 , Subject 150.		
	Voltage is between 11 and 13 volts.	Go to the next row in the table.		
Remove the X3 (electric motor 2-pin) connector from the transmission control unit (TCU). Check the electric motor power circuit.	2	1 X3 f544485		
Check for voltage between pin 1 (power circuit 232) of the X3 connector and the battery ground terminal.	Voltage drops more than 0.2 volts from the voltage measured at the battery.	Repair or replace the wiring as needed. See Section 54.06 , Subject 100.		
	Voltage is within 0.2 volts of the voltage measured at the battery.	Go to the next row in the table.		

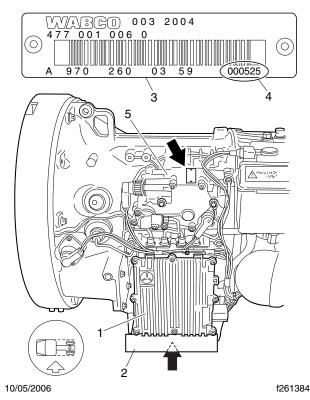
Electrical Pre-Test				
Procedure	Result	Action		
Check for resistance between pin 2 (ground) of the X3 connector and the battery ground terminal.	Resistance is greater than 0.3 ohms.	Repair or replace the wiring as needed. See Section 54.06 , Subject 100.		
	Resistance is 0.3 ohms or less.	Go to the next row in the table.		
Remove the X1 (vehicle 21-pin) connector from the transmission control unit (TCU). Check the battery power circuit.	19 16 13 1	2 9 6 3 1 8 5 2 0 7 4 1		
Check for voltage from pins 12 and 15 (battery power circuit 232D) of the X1 connector to the battery ground terminal.	Voltage drops more than 0.2 volts from the voltage measured at the battery. Voltage is within 0.2 volts of the	Repair or replace the wiring as needed. See Section 54.06 , Subject 100. Go to the next row in the table.		
	voltage measured at the battery.	Go to the float few in the table.		
Turn on the ignition switch. Check the ignition power circuit.	20 17 14 1 19 16 13 1	1 8 5 2		
Check for voltage from pin 9 (ignition power circuit 232E) of the X1 connector to the battery ground terminal.	Voltage drops more than 0.2 volts from the voltage measured at the battery.	Repair or replace the wiring as needed. See Section 54.06 , Subject 100.		
	Voltage is within 0.2 volts of the voltage measured at the battery.	Go to the next row in the table.		

	Electrical Pre-Test			
Procedure	Result	Action		
Turn off the ignition switch. Check the ignition ground circuit.	20 17 14 19 16 13			
With the ignition switch off, check for resistance between pins 18 and 21 (ground) of the X1 connector and the better ground torminal	Resistance is greater than 0.3 ohms.	Repair or replace the wiring as needed. See Section 54.06 , Subject 100.		
battery ground terminal.	Resistance is 0.3 ohms or less.	Go to the next row in the table.		
Turn off the ignition switch. Check the J1587 wiring.	21 18 15 1 20 17 14 1 19 16 13	10 7 4 1		
	07/21/2004	f544483e		
Check for DC voltage from pins 11 and 14 (J1587 datalink) of the X1 connector to the battery ground terminal.	Voltage is less than 1 or more than 4 volt(s) for DC (less than 1 or more than 3 for AC).	Troubleshoot the J1587 datalink.		
NOTE: If the meter cannot display the rapidly shifting DC voltage, measure AC voltage instead.	Voltage is between 1 and 4 volts for DC (1-3 volts AC).	Go to the next row in the table.		
Turn off the ignition switch. Check the J1939 wiring.	21 18 15 1 20 17 14 1 19 16 13	11 8 5 2 		

Electrical Pre-Test				
Procedure	Result	Action		
With the ignition switch off, remove the X1 connector from the TCU and check for	Resistance is less than 55 or greater than 65 ohms.	Troubleshoot the J1939 datalink. See Freightliner Service Bulletin 54-133 .		
resistance between pins 7 and 13 (J1939 datalink).	Resistance is between 55 and 65 ohms.	The vehicle has passed the electrical pre-test. Troubleshoot active fault codes, if any.		

Table 1, Electrical Pre-Test

NOTE: To see the identification plate on the TCU it may be necessary to remove the splash guard.



NOTE: The TCU and X-Y Actuator each have their own WABCO identification plate (arrows) with unique serial numbers.

- 1. TCU (Transmission Control Unit)
- 2. Splash Guard
- WABCO Identification Plate
- 4. Serial Number
- 5. X-Y Actuator

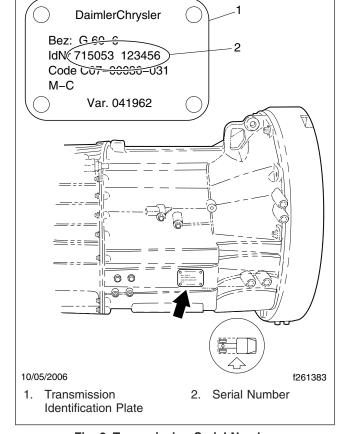


Fig. 2, Transmission Serial Number

Troubleshooting Tables, No Fault Codes

In a few cases there will be a definite problem and no J1587 fault code will be sent.

• If the engine will not crank and there are no transmission fault codes, see **Table 2**.

- If the current gear indicator displays "FL," and the CHECK TRANS light comes on, there is a low fluid level fault. See Table 3. Low fluid level faults do not generate a J1587 fault code.
- If the transmission is fully functional, but there is no information on the current gear indicator, see **Table 4**.

No J1587 Fault Code—The Engine Will Not Crank					
Procedure	Result	Action			
Make sure that the selector switch on the SmartShift lever is set	The current gear display shows "N."	Verify that the BHM is correctly programmed to allow for "AGS start enabling" and that the J1939 communications systems is functioning properly.			
to N. Power up the transmission.	There is a J1587 fault code in MID 128 (engine) for missing J1939 information.	Check the wiring for loose terminals and corroded connector pins.			
	The gear display is blank and there is no response to the J1587 roll call. The hydraulic pump does not come on.	Check pin 9 on the X1 connector to verify the presence of ignition voltage.			
	There is a J1587 roll call and it reports other ECUs but not the TCU.	Go to the next row in the table.			
Remove the X1 connector and check it	Pins are damaged or missing.	Straighten bent pins and replace a damaged connector.			
for bent or missing pins.	The connector is intact and serviceable.	Go to the next row in the table.			
Check both	Either or both fuses are blown.	Replace any blown fuses.			
transmission fuses in the bulkhead module.	The fuses are good.	Go to the next row in the table.			
Check the datalink communication again.	There is no datalink communication.	Check for a wiring problem (most likely at a common connector).			
	The datalink is OK.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.			
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.			
		1. Using ServiceLink, print the AGS codes (130).			
		2. Complete the electrical pre-test result sheet. See Fig. 3.			
		3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@Freightliner.com), or phone (503.745.4965 or 503.745.4988).			

Table 2, The Engine Will Not Crank

No J1587 Fault Code—"FL" on Current Gear Indicator; CHECK TRANS Light Illuminates*				
Problem	Procedure	Result/Action		
The hydraulic fluid level is low.		If the fluid level is low, add Pentosin to the hydraulic reservoir.		

No J1587 Fault Code—"FL" on Current Gear Indicator; CHECK TRANS Light Illuminates*					
Problem	Procedure	Result/Action			
The fluid level sensor is defective.	Disconnect the sensor connector from the reservoir cap. Check for continuity across pins 1 and 2 of the sensor connector.	If no continuity, replace the sensor. See Subject 150 .			
	NOTE: When the reservoir is full, the float in the sensor rises up, and the two pins in the connector create a complete circuit.				
Turn off the ignition switch. Check the fluid level sensor wiring.	1 4 7 10 13 2 5 8 11 14 3 6 9 12 15 H H H	n n			
	07/16/2004 X2	f544484l			
The wiring between the TCU and the fluid level sensor is defective.	Check resistance from pin 4 on the X2 connector to pin 2 on the sensor connector. Check resistance from pin 12 on the X2 connector to pin 1 on the sensor connector.	If no resistance, repair or replace the X2 transmission harness. See Subject 180 .			
There is an internal electrical failure in the TCU.	Check the TCU for leakage or damage.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.			
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.			
		1. Using ServiceLink, print the AGS codes (130).			
		2. Complete the electrical pretest result sheet. See Fig. 3.			
		3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).			

^{*} Even though the CHECK TRANS light illuminates, it is normal to see no active fault code.

Table 3, Low Fluid Level Indication

No J1587 Fault Code—Transmission Fully Functional; No Information on Current Gear Indicator					
Problem	Procedure	Result	Action		
The wiring from the X1 connector to the current gear indicator is defective.	Power up the transmission.	The current gear indicator displays ""	Repair or replace the X1 connector harness as needed. See Section 54.06, Subject 100.		
		The current gear indicator displays something other than ""	See the messages in Table 5 for possible error codes.		
Remove the X2 connector wiring.	. Check the speed sensor	08/11/2005 X2 f544484m			
The wiring from the output shaft speed sensor to the current	output shaft speed pin 15 on the X2 connector		Replace the X2 wiring harness. See Subject 180 .		
gear indicator is shorted to ground.	sensors.	At least one speed sensor is OK.	Go to the next row in the table.		
The wiring from the X1 connector to the J1587 communication on datalink is defective. Check for J1587 communication on ServiceLink.		AGS2 is not reporting on ServiceLink.	Repair or replace the X1 connector wiring as needed. See Section 54.06, Subject 100.		
			Go to the next row in the table.		
The current gear indicator or its wiring is defective. Check the wiring from the current gear indicator to power, ground, and the J1587 datalink.		The wiring is damaged. Repair or replace the properties of the pr			
		The wiring is OK.	Replace the current gear indicator.		

Table 4, Transmission Fully Functional; No Information on Current Gear Indicator

AGS Messages on the Current Gear Indicator				
Code Error				
SM	System Malfunction (this is a code that could affect driveability)			
CO	Clutch Overload (clutch has begun to overheat)			
FL	Low Hydraulic Fluid Level			

AGS Messages on the Current Gear Indicator				
Code	Error			
	Undefined Gear Position			
X	Incomplete Calibration			
	Gear or Rail Position Sensor Error			
""	No J1587 Communication			
"/blank saraan)"	No Power to Gear Display			
"(blank screen)"	No J1587 Communication			
N	Normal Operation (neutral gear)			
R	Normal Operation (reverse gear)			
1-6	Normal Operation (forward gears)			

Table 5, AGS Messages on the Current Gear indicator

			Se		ımbers				
TCU:				X-Y	Actuator:				
AGS:									
ABS	SID/P	ID	FMI		Eng	SID	/PID	FMI	
Codes:					Codes:				
(136)					(128)				
Pentosin	Full	Below A	bove Gear		Yes	No	Gear	Yes	No
level:			eam displ				display	103	
(with			powe				show		
	Empty	. – .					"N":		
depres-		inches	nches						
surized)									
Customer			l				1	-1	-
complaint									
description	ո։								
Battery			Battery			Grou	ınd at		
voltage:			voltage at			X3 p	in 2:		
J			X3 pin 1:						
Key power			Battery			Grou	ınd at		
at X1 pin			voltage at				ins 18		
9:			X1 pins 1	2		& 21	:		
			& 15:						
J1587	OK	Failed	J1939	OK	Failed				
Datalink			Datalink		1_				
			good:						
good:									

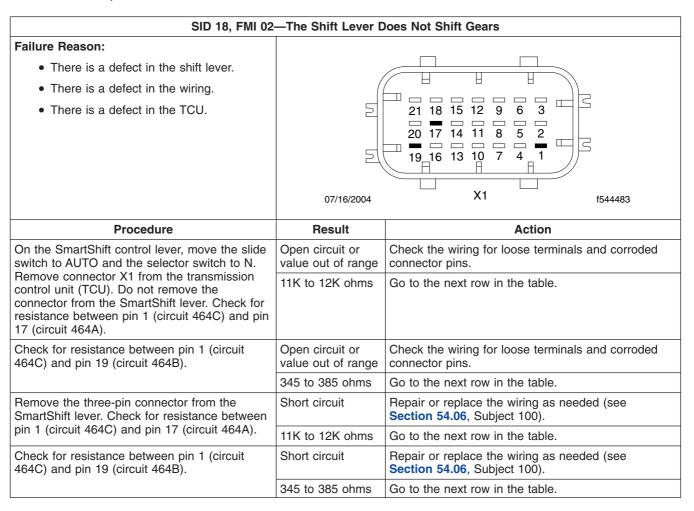
Fig. 3, Electrical Pre-Test Result Sheet

SmartShift Fault (SID 18)

SmartShift Fault

There is one SmartShift fault covered in these procedures. In addition to the troubleshooting table, two tables of resistance values are provided.

- For SID 18, FMI 02, see Table 1 for procedures and pin identification.
- To check resistance on the SmartShift up/ downshift circuit, see Table 2.
- To check resistance on the SmartShift gear selection circuit, see **Table 3**.



SmartShift Fault (SID 18)

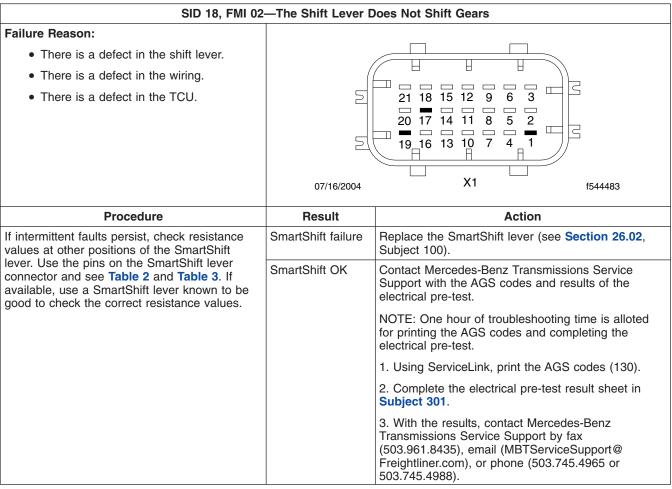


Table 1, The Shift Lever Does Not Shift Gears

Resistance Check for the Up/Downshift Circuit (Pin A to Pin C)				
Slide Switch + Lever Position Reading: kOhr				
AUTO	10.969–12.084			
MAN	2.838-3.020			
MAN + Up	0.527-0.564			
MAN + Down	1.142–1.213			
AUTO + Up	0.611-0.653			
AUTO + Down	1.628-1.729			

Table 2, Resistance Check for the Up/Downshift Circuit

Resistance Check for the Gear Selection Circuit (Pin B to Pin C)				
Selector Switch Position Reading: kOhm				
R	2.922-3.100			
N	0.342-0.389			
D	0.576-0.670			

Table 3, Resistance Check for the Gear Selection Circuit

Hydraulic Pressure Sensor Faults (SID 33)

Hydraulic Pressure Sensor Faults

• For SID 33, FMI 03, FMI 04, and FMI 05, see **Table 1** for procedures.

There are three hydraulic pressure sensor faults covered in these procedures. The same troubleshooting procedure is used for all.

SID 33, FMI 03, 04, 05—The Pressure Sensor Is Shorted or Open

- The contacts on the pressure sensor terminal are not straight.
- There is a defect in the pressure sensor.
- There is a defect in the TCU.

Procedure	Result	Action
Do a visual check of the pressure sensor connector.	The pressure sensor contacts are bent or crooked.	Straighten any bent pins or plugs.
	The contacts are OK.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.
		1. Using ServiceLink, print the AGS codes (130).
		2. Complete the electrical pre-test result sheet in Subject 301 .
		3. With the results, contact Mercedes- Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).

Table 1, The Pressure Sensor Is Shorted or Open

Hydraulic Pump Faults (SID 52)

Hydraulic Pump Faults

There are three hydraulic pump faults covered in these procedures. FMI 05 and FMI 07 are covered by the same troubleshooting procedure.

When both fault codes (SID 52 FMI 05 and SID 52 FMI 07) are active at the same time, a wiring problem is the most likely cause.

- For SID 52, FMI 05 and FMI 07, see Table 1 for procedures.
- For SID 52, FMI 11, see Table 2 for procedures.

SID 52, FMI 05, 07—The Hydraulic Pump Pressure Does Not Increase

- The hydraulic fluid level is low.
- The hydraulic system is leaking.
- There is air in the hydraulic system.
- The fuse in connector X3 is blown.
- The accumulator has failed.
- The pump or pressure sensor has failed.
- The hydraulic lines are pinched, kinked, or blocked.
- The TCU has failed.

Problem	Remedy		
Problem	Procedure	Action	
The hydraulic fluid level is low.	Check the hydraulic fluid level.	Add Pentosin to the hydraulic reservoir.	
There are leaks in the hydraulic system.	Do a visual check of the hydraulic system for leaks and loose fittings. Tug on all the hydraulic fittings to make sure they are properly fastened.	Replace any leaking or damaged tubing. Make sure all the hydraulic fittings are properly fastened. See Subject 200 for procedures.	
There is air in the hydraulic system.	Bleed the hydraulic system. See Subject 130 for procedures.	Test the hydraulic pump and make sure the pressure does increase.	
The hydraulic pump circuit is open.	Check the 40-amp fuse. Remove the X3 connector and check the wiring at both pins.	Replace the 40-amp fuse if necessary. Repair or replace the wiring if necessary.	
The pressure accumulator has failed.	Check the pressure accumulator for leaks or damage.	Replace the pressure accumulator. See Subject 140 for procedures.	

Hydraulic Pump Faults (SID 52)

SID 52, FMI 05, 07—The Hydraulic Pump Pressure Does Not Increase

Failure Reason:

- The hydraulic fluid level is low.
- The hydraulic system is leaking.
- There is air in the hydraulic system.
- The fuse in connector X3 is blown.
- The accumulator has failed.
- The pump or pressure sensor has failed.
- The hydraulic lines are pinched, kinked, or blocked.
- The TCU has failed.

Droblem	Remedy			
Problem	Procedure	Action		
The pump or pressure sensor has failed, or there is an internal electrical failure in the TCU.	Check the AGS central unit for leakage or damage.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.		
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.		
		1. Using ServiceLink, print the AGS codes (130).		
		2. Complete the electrical pre-test result sheet in Subject 301 .		
		3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).		

Table 1, The Hydraulic Pump Pressure Does Not Increase

SID 52, FMI 11—The Hydraulic Pump Temperature Is Too High

- The pump motor has been operating for too long.
- There has been a failure of the hydraulic system.

Problem	Remedy		
Problem	Procedure	Action	
The pump motor is overheated.		If the fault goes away, and there are no other active fault codes, no action is needed.	

Hydraulic Pump Faults (SID 52)

SID 52, FMI 11—The Hydraulic Pump Temperature Is Too High

- The pump motor has been operating for too long.
- There has been a failure of the hydraulic system.

Problem	Remedy			
Problem	Procedure	Action		
There has been a failure of the hydraulic system. Failure is persistent and continues under all conditions.	Check the hydraulic system for leaks and troubleshoot other fault codes.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.		
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.		
		1. Using ServiceLink, print the AGS codes (130).		
		2. Complete the electrical pre-test result sheet in Subject 301 .		
		3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).		

Table 2, The Hydraulic Pump Temperature Is Too High

Clutch Actuator Faults (SID 55)

Clutch Actuator Faults

There are three clutch actuator faults covered in these procedures. Each one requires a different troubleshooting procedure. FMI 00 is often a temporary fault that goes away when the clutch is allowed to cool.

- For SID 55, FMI 00, see Table 1 for procedures.
- For SID 55, FMI 07, see Table 2 for procedures.
- For SID 55, FMI 13, see Table 3 for procedures

SID 55, FMI 00-The Clutch Is Too Hot*

Failure Reason:

- The clutch has temporarily overheated due to excessive use.
- There is a fault in the clutch actuator sensor.
- There is a mechanical defect in the clutch system.

Problem	Procedure	Result	Action
The clutch is too hot. NOTE: Excessive clutch use may have been caused by maneuvering in heavy	Allow the clutch to cool.	Fault code goes away after clutch has cooled.	No corrective action is needed.
traffic or using the clutch to hold the truck on a hill.		Fault code does not go away after clutch has cooled.	Go to the next step in the table.
There is a problem with an output shaft speed sensor.	Check for other MID 130 (transmission) fault codes.	Other fault codes are active.	Troubleshoot the other active fault codes.
		No other fault codes are active.	Go to the next step in the table.
The clutch is slipping.	Test drive the vehicle. Is the fault code active during normal driving conditions (without a lot of gear changes)?	The fault code remains active.	Check the mechanical components of the clutch system. See Section 25.02 .

^{*} When this fault appears, it is usual to see the CHECK TRANS light illuminate and "CO" (clutch overload) display on the current gear indicator.

Table 1, The Clutch Is Too Hot

SID 55, FMI 07—The Clutch Does Not Operate Properly

- The hydraulic system is leaking.
- There is a defect in the clutch actuator.
- There is a mechanical defect in the clutch system.
- There is a mechanical defect in the solenoid valves of the AGS central unit.

Problem	Procedure	Result	Action
There are other active transmission faults.	Check for other MID 130 fault codes.	Other fault codes are active.	Troubleshoot the other active fault codes.
		No other fault codes are active.	Go to the next step in the table.

Clutch Actuator Faults (SID 55)

SID 55, FMI 07—The Clutch Does Not Operate Properly

- The hydraulic system is leaking.
- There is a defect in the clutch actuator.
- There is a mechanical defect in the clutch system.
- There is a mechanical defect in the solenoid valves of the AGS central unit.

Problem	Procedure	Result	Action
The hydraulic system is leaking or fluid flow	Do a visual check of the fluid lines for leaks, kinked	Leaks, kinked lines, or blockage is found.	Make sure all lines are tight. Replace any damaged components.
is restricted to the clutch actuator.	lines, or blockage.	There are no defects in the fluid lines.	Go to the next step in the table.
The clutch is slipping.	Test drive the vehicle. Does the system respond well to a wide range of	There are problems changing gears (shuddering, noises, slow to shift).	Check the mechanical components of the clutch system. See Section 25.02.
	driving condition and gear changes?	There are no problems.	Replace the clutch actuator. See Subject 120.
There is a mechanical defect in the solenoid valves.	Test drive the vehicle. Is the fault code active during normal driving conditions (without a lot of	The fault code remains active.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.
	gear changes)?		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.
			1. Using ServiceLink, print the AGS codes (130).
			2. Complete the electrical pre-test result sheet in Subject 301 .
			3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).
		No fault codes.	Complete a learning procedure using ServiceLink.

Table 2, The Clutch Does Not Operate Properly

Clutch Actuator Faults (SID 55)

SID 55, FMI 13—The Clutch Needs To Be Calibrated

- The clutch is not calibrated properly.
- There is a mechanical defect in the clutch system.

Problem	Procedure	Result	Action
Missing or incomplete clutch calibration (often	Complete a learning procedure using either ServiceLink or the SmartShift control.	The fault is no longer active.	No action is needed.
occurs after service procedures such as clutch replacement,	To complete a learning procedure using the SmartShift control:	The fault is still active.	Go to the next step in the table.
clutch actuator	1. Ensure that the parking brake is set.		
replacement, or engine/ transmission separation).	2. With the ignition turned off, pull and hold the SmartShift control toward steering wheel.		
	NOTE: The SmartShift control must be kept in this position until the gear display clears at the end of the procedure.		
	3. Turn on the ignition. The normal warm up procedure will initiate and an 'X' will display on the current gear indicator. Your transmission may be heard shifting.		
	4. Wait until the current gear indicator displays an 'N' (about 30 seconds) and an audible alert sounds. Start the engine within 10 seconds of the audible alert.		
	5. The engine will raise a few rpm, then fall back to idle, and an audible alert will sound. Turn off the engine within 10 seconds of audible alert. When the gear display clears, this procedure is complete.		
	NOTE: If during this procedure an 'SM' or 'X' (after the warm up procedure) appears in the gear display, stop, turn off the ignition, and wait for the gear display to go dark. Then start over. This may need to be repeated several times.		
There are other active transmission faults.	Check for other MID 130 fault codes.	Other fault codes are active.	Troubleshoot the other active fault codes.
		No other fault codes are active.	Check the mechanical components of the clutch system. See Section 25.02.

Table 3, The Clutch Needs To Be Calibrated

J1939 Datalink Faults (SID 231)

J1939 Datalink Faults

There are three J1939 datalink faults covered in these procedures. If more than one of these faults is active, check FMI 12 first for best results. This can often resolve the other two faults as well.

For SID 231, FMI 02, see Table 1 for procedures.

- For SID 231, FMI 09, see Table 2 for procedures
- For SID 231, FMI 12, see **Table 3** for procedures and pin identification.

SID 231, FMI 02—The J1939 Datalink Is Not Communicating Properly

Failure Reason:

- There has been a failure in the data content received by the J1939 datalink from the other control units (engine ECU, bulkhead module, ABS ECU).
- The J1939 wiring is defective.
- There is interference from other control units on the J1939 datalink.

Problem	Procedure	Result	Action
There is no power to the transmission.	Check for fault code SID 231, FMI 09 and/or SID 231, FMI 12.	SID 231, FMI 09 and/or 12 are (is) active.	Troubleshoot SID 231, FMI 09 and/or 12. See Table 2 and/or Table 3 .
		SID 231, FMI 09 and 12 are not active.	Go to the next step in the table.
The J1939 data are not plausible.	Check the J1939 datalink connections to other systems, particularly the engine (MID 128), the antilock brakes (MID 136) and the bulkhead module (MID 164).	There are other problems with the J1939 datalink.	Troubleshoot the J1939 datalink. See Freightliner Service Bulletin 54-133.

Table 1, The J1939 Datalink Is Not Communicating Properly

SID 231, FMI 09—The J1939 Datalink Message Has Timed Out

- The J1939 datalink is not receiving messages from other control units (engine ECU, bulkhead module, ABS ECU).
- The J1939 wiring is defective.
- There is interference from other control units on the J1939 datalink.

Problem	Procedure	Result	Action
The power supply has been interrupted.	Check for fault code SID 231, FMI 12.	SID 231, FMI 12 is active.	Troubleshoot SID 231, FMI 12. See Table 3 .
		SID 231, FMI 12 is not active.	Go to the next step in the table.
Other active fault codes are causing a	Check for other active fault codes in other systems.	Other active fault codes are found.	Troubleshoot the other active fault codes.
breakdown in J1939 communications.		No other active fault codes are found.	Go to the next step in the table.

J1939 Datalink Faults (SID 231)

SID 231, FMI 09—The J1939 Datalink Message Has Timed Out

Failure Reason:

- The J1939 datalink is not receiving messages from other control units (engine ECU, bulkhead module, ABS ECU).
- The J1939 wiring is defective.
- There is interference from other control units on the J1939 datalink.

Problem	Procedure	Result	Action
not plausible.	Check the J1939 datalink connections to other systems, particularly the engine (MID 128), the antilock brakes (MID 136) and the bulkhead module (MID 164).	There are other problems with the J1939 datalink.	Troubleshoot the J1939 datalink. See Freightliner Service Bulletin 54-133.

Table 2, The J1939 Datalink Message Has Timed Out

SID 231, FMI 12—The J1939 Datalink Is Not Communicating With the Transmission Failure Reason: • The J1939 datalink has defective components. • The terminating resistors on the J1939 back-6 3 bone are missing, or there are extra resistors. 15 21 18 • The J1939 wiring is defective. 20 17 14 8 5 11 • The signal on the J1939 datalink is distorted. 10 19_16 13 • There is a defect in the TCU. X1 07/16/2004 f544483a **Problem Procedure** Result **Action** Pins on the connector Remove the X1 connector. The connector has been Straighten any bent pins. Repair or replace the connector. have been bent or Visually inspect the pins and damaged. damaged. connector. The connector has not been Go to the next step in the table. damaged. The J1939 datalink is With the X1 connector The resistance is less than Troubleshoot the J1939 datalink. defective. removed, check for 54 or more than 66 ohms. See Freightliner Service Bulletin resistance between pin 7 54-133. and pin 13. The resistance is between 54 Go to the next step in the table. and 66 ohms. There is a short circuit With the X1 connector A short circuit is found. Check the J1939 wiring behind pins in the J1939 wiring. removed, check for 7 and 13 and repair it as needed. resistance between pin 7 An open circuit is found. Go to the next step in the table. and all other pins on the connector.

J1939 Datalink Faults (SID 231)

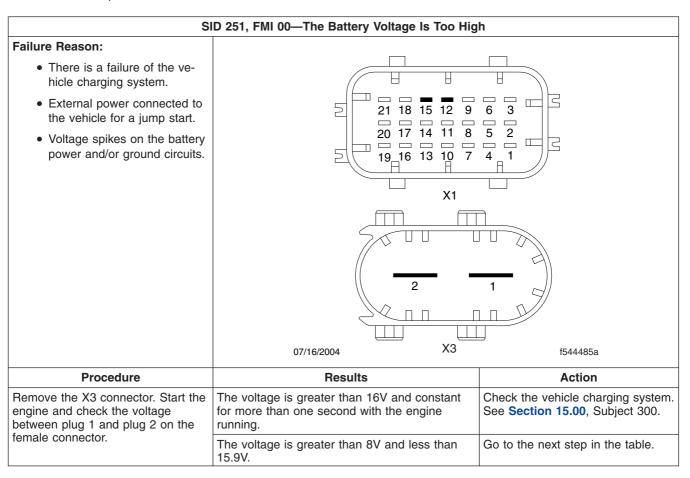
SID 231, FMI 12—The J1939 Datalink Is Not Communicating With the Transmission Failure Reason: • The J1939 datalink has defective components. • The terminating resistors on the J1939 back-3 bone are missing, or there are extra resistors. 6 9 21 18 15 12 5 8 • The J1939 wiring is defective. 14 11 • The signal on the J1939 datalink is distorted. 16 13 • There is a defect in the TCU. X1 07/16/2004 f544483a **Problem** Result **Action Procedure** There is a wiring With the X1 connector SID 231, FMI 12 is active for Troubleshoot the J1939 datalink for failure in the TCU. removed, check whether the other systems. See Freightliner other systems (MIDs). other systems have the Service Bulletin 54-133. identical fault code active Contact Mercedes-Benz This fault is not active for (SID 231, FMI 12). other systems (MIDs). Transmissions Service Support with the AGS codes and results of the electrical pre-test. NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test. 1. Using ServiceLink, print the AGS codes (130). 2. Complete the electrical pre-test result sheet in Subject 301. 3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).

Table 3, The J1939 Datalink Is Not Communicating With the Transmission

Battery Power Supply Faults

There are four battery power supply faults covered in these procedures. Each one requires a different electrical test.

- For SID 251, FMI 00, see Table 1 for procedures and pin identification.
- For SID 251, FMI 01, see **Table 2** for procedures and pin identification.
- For SID 251, FMI 05, see **Table 3** for procedures and pin identification.
- For SID 251, FMI 14, see **Table 4** for procedures and pin identification.



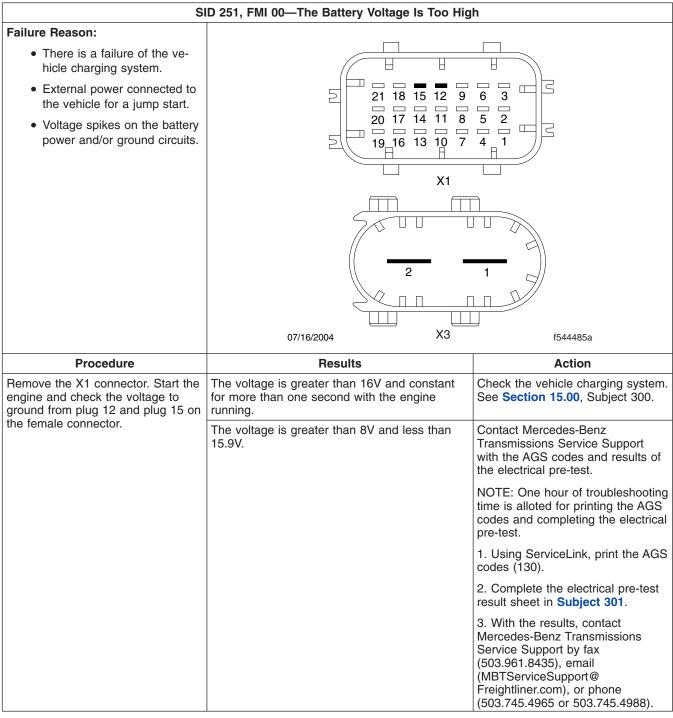
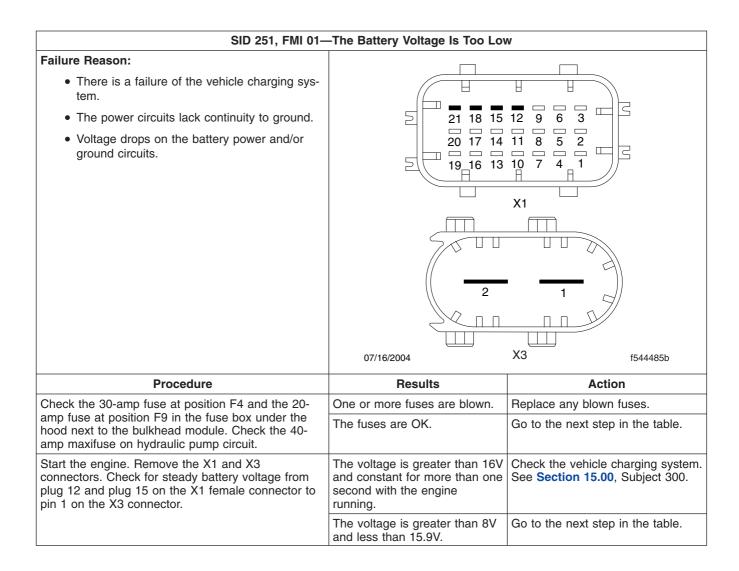


Table 1, The Battery Voltage Is Too High



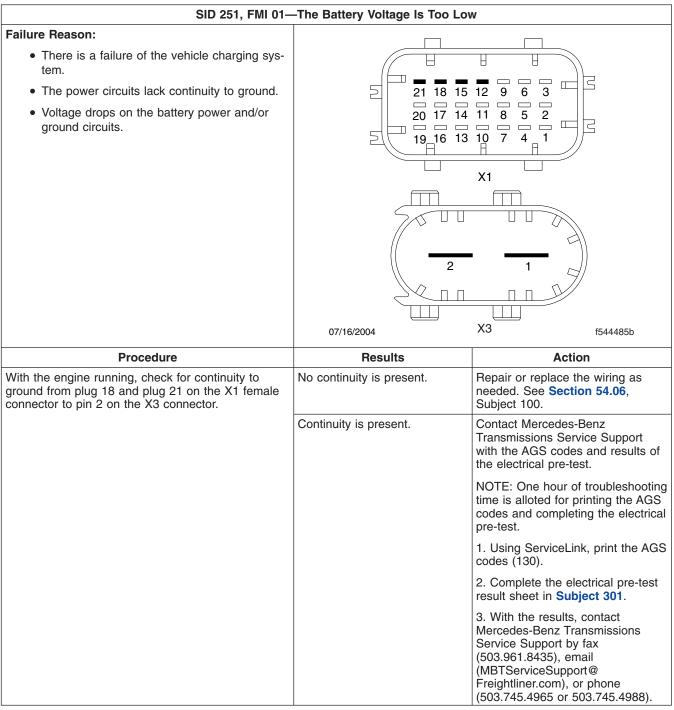
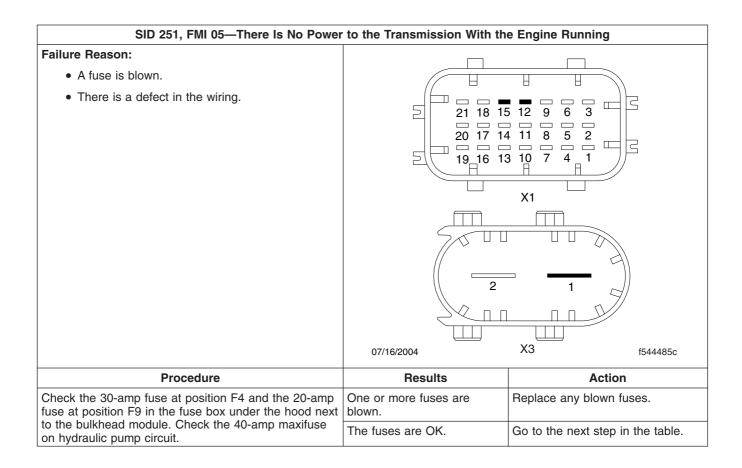


Table 2, The Battery Voltage Is Too Low



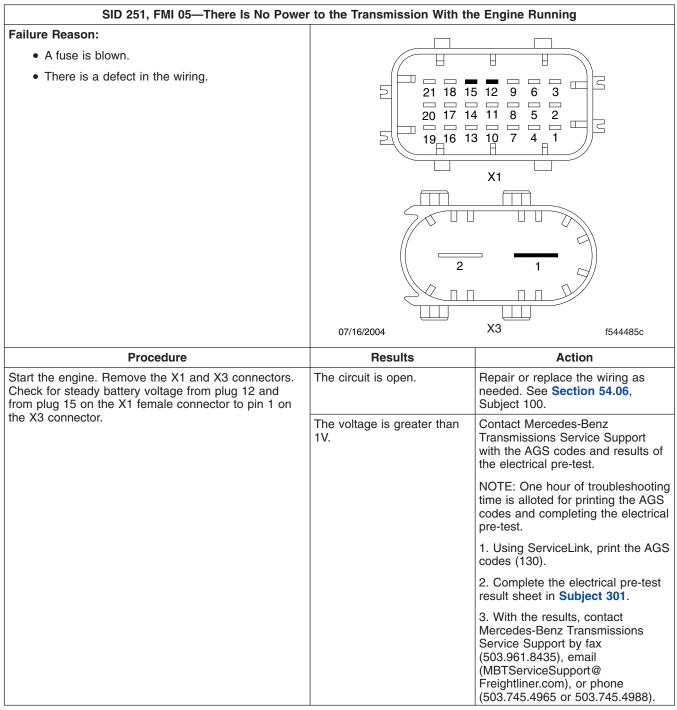


Table 3, There Is No Power to the Transmission With the Engine Running

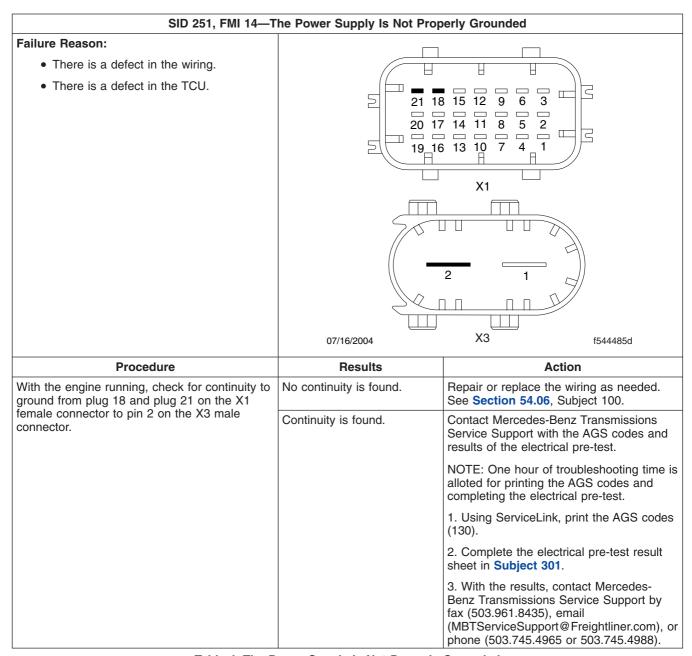


Table 4, The Power Supply Is Not Properly Grounded

Calibration Memory Faults (SID 253)

Calibration Memory Faults

There are four calibration memory faults covered in these procedures. The same troubleshooting procedure is used for all. • For SID 253, FMI 02, FMI 12, FMI 13, and FMI 14, see **Table 1** for procedures.

SID 253, FMI 02, 12, 13, 14—The Transmission Needs To Be Recalibrated

- There is a failure of programmable memory.
- The transmission has not been properly calibrated, or the calibration procedure failed.
- The TCU has suffered an internal electrical failure.

Procedure	Result	Action
Complete a learning procedure using either	Calibration is successful.	No further action is needed.
ServiceLink or the SmartShift control. To complete a learning procedure using the SmartShift control:		Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.
Ensure that the parking brake is set.		NOTE: One hour of troubleshooting
2. With the ignition turned off, pull and hold the SmartShift control toward steering wheel.		time is alloted for printing the AGS codes and completing the electrical
NOTE: The SmartShift control must be kept in this position until the gear display clears at the end of the procedure.		pre-test. 1. Using ServiceLink, print the AGS
3. Turn on the ignition. The normal warm up procedure will initiate and an 'X' will display on the current gear indicator. Your transmission may be heard shifting.		codes (130). 2. Complete the electrical pre-test result sheet in Subject 301 .
4. Wait until the current gear indicator displays an 'N' (about 30 seconds) and an audible alert sounds. Start the engine within 10 seconds of the audible alert.		3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email
5. The engine will raise a few rpm, then fall back to idle, and an audible alert will sound. Turn off the engine within 10 seconds of audible alert. When the gear display clears, this procedure is complete.		(MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).
NOTE: If during this procedure an 'SM' or 'X' (after the warm up procedure) appears in the gear display, stop, turn off the ignition, and wait for the gear display to go dark. Then start over. This may need to be repeated several times.		

Table 1, The Transmission Needs To Be Recalibrated

Transmission Control Unit Faults

There are five transmission control unit (TCU) faults covered in these procedures. FMI 04 and FMI 05 are covered by the same procedure.

 For SID 254, FMI 04 and FMI 05, see Table 1 for procedures.

- For SID 254, FMI 11, see **Table 2** for procedures.
- For SID 254, FMI 12, see **Table 3** for procedures.
- For SID 254, FMI 13, see Table 4 for procedures

SID 254, FMI 04, 05—The TCU Is Shorted to Ground or Open

- There is a short circuit to ground in the solenoid valve.
- There is an open circuit in the solenoid valve.

There is an open circuit in the solenou vaive.				
Procedure	Results	Action		
Turn the ignition switch off and wait for the current gear indicator to power down. Turn the switch on and check to see if the fault is still active.	The fault has become inactive.	No action is needed.		
	The fault is still active.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.		
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.		
		1. Using ServiceLink, print the AGS codes (130).		
		2. Complete the electrical pre-test result sheet in Subject 301 .		
		3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).		

Table 1, The TCU Is Shorted to Ground or Open

SID 254, FMI 11—The TCU AUTO Mode Software Module Has an Error

- The engine ECU is not providing valid data.
- There is faulty data in programmable memory (EEPROM).
- The SmartShift lever is defective.
- One of the shift position sensors (gear or rail) has failed.
- One of the output shaft speed sensors has failed.
- The transmission is not properly calibrated.
- There is a defect in the brake pedal switch.
- There is a defect in the throttle pedal switch.

Problem	Procedure	Result	Action
The TCU is receiving faulty data.	Check for other MID 130 fault codes.	Other fault codes are active.	Troubleshoot the other active fault codes.
		No other fault codes are active.	Go to the next step in the table.
The transmission needs to be	Complete a learning procedure using either ServiceLink or the SmartShift control.	The fault is no longer active.	No further action is needed.
recalibrated.	To complete a learning procedure using the SmartShift control:	The fault is still active.	Go to the next step in the table.
	1. Ensure that the parking brake is set.		
	2. With the ignition turned off, pull and hold the SmartShift control toward steering wheel.		
	NOTE: The SmartShift control must be kept in this position until the gear display clears at the end of the procedure.		
	3. Turn on the ignition. The normal warm up procedure will initiate and an 'X' will display on the current gear indicator. Your transmission may be heard shifting.		
	4. Wait until the current gear indicator displays an 'N' (about 30 seconds) and an audible alert sounds. Start the engine within 10 seconds of the audible alert.		
	5. The engine will raise a few rpm, then fall back to idle, and an audible alert will sound. Turn off the engine within 10 seconds of audible alert. When the gear display clears, this procedure is complete.		
	NOTE: If during this procedure an 'SM' or 'X' (after the warm up procedure) appears in the gear display, stop, turn off the ignition, and wait for the gear display to go dark. Then start over. This may need to be repeated several times.		

SID 254, FMI 11—The TCU AUTO Mode Software Module Has an Error

Failure Reason:

- The engine ECU is not providing valid data.
- There is faulty data in programmable memory (EEPROM).
- The SmartShift lever is defective.
- One of the shift position sensors (gear or rail) has failed.
- One of the output shaft speed sensors has failed.
- The transmission is not properly calibrated.
- There is a defect in the brake pedal switch.
- There is a defect in the throttle pedal switch.

Problem	Procedure	Result	Action
The brake pedal switch is defective.	Use the ServiceLink AGS template to check the functionality of the brake pedal switch.	The template does not show brake pedal activation.	Check the function of the brake pedal. See Section 25.02 for procedures.
		The template shows brake pedal activation.	Go to the next step in the table.
The throttle pedal switch is defective.	Use the ServiceLink AGS template to check the functionality of the throttle pedal switch.	The template does not show throttle pedal activation.	Check the function of the throttle pedal. See Section 25.02 for procedures.
		The template shows throttle pedal activation.	Contact Freightliner Technical Service Support.

Table 2, The TCU AUTO Mode Software Module Has an Error

SID 254, FMI 12—The TCU Has a Hardware Problem

- There is a short circuit to ground in the external power supply.
- There is a short circuit to ground through the output shaft speed sensor.
- There has been an internal hardware failure of the TCU.

Problem	Procedure	Result	Action
The power supply is short-circuited to ground.	Remove the X1 connector. Check for short circuit to ground from pin 6.	The current gear indicator displays something other than "N" and/or there are speed sensor error codes.	Repair or replace the wiring as needed. See Section 54.06 , Subject 100.
		The current gear indicator displays "N."	Go to the next step in the table.
short-circuited Check for short circuit to ground from pin 15.		There are no active speed sensor (PID 191) error codes.	Repair or replace the wiring as needed. See Section 54.06 , Subject 100.
shaft speed sensor.		There are active speed sensor (PID 191) error codes.	Go to the next step in the table.

SID 254, FMI 12—The TCU Has a Hardware Problem

- There is a short circuit to ground in the external power supply.
- There is a short circuit to ground through the output shaft speed sensor.
- There has been an internal hardware failure of the TCU.

Problem	Procedure	Result	Action
There has been an internal electrical	Turn off the ignition switch, wait for the current gear	The fault is no longer active.	Troubleshoot the other active fault codes.
problem of the TCU.	indicator to power down, and turn the ignition switch on again.		Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.
			NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.
			1. Using ServiceLink, print the AGS codes (130).
			2. Complete the electrical pretest result sheet in Subject 301 .
			3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).

Table 3, The TCU Has a Hardware Problem

SID 254, FMI 13—The TCU Has a Software Memory Problem				
Failure Reason:				
There has bee	n an internal software failure of the TCU			
Problem	Procedure	Result	Action	
There has been an internal electrical	3 · · · · · · · · · · · · · · · · · · ·	The fault is no longer active.	Continue to monitor the TCU.	
problem of the ICU.		The fault is still active.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.	
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.		
			1. Using ServiceLink, print the AGS codes (130).	
		2. Complete the electrical pretest result sheet in Subject 301 .		
			3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).	

Table 4, The TCU Has a Software Memory Problem

Clutch Position Sensor Faults

There are five clutch position sensor faults covered in these procedures. Each one requires a separate electrical test.

- For PID 33, FMI 02, see **Table 1** for procedures and pin identification.
- For PID 33, FMI 03, see **Table 2** for procedures and pin identification.

- For PID 33, FMI 04, see **Table 3** for procedures and pin identification.
- For PID 33, FMI 05, see **Table 4** for procedures and pin identification.
- For PID 33, FMI 14, see **Table 5** for procedures and pin identification.

	PID 33, FMI 02—The Clutch Position Sensor Is Providing Invalid Data					
 Failure Reason: There is a defect in the wiring. There is a defect in the clutch position sensor. There is a defect in the TCU. 		07/16/2004 X2 f544484b				
Problem	Procedure	Result	Action			
Pins on the X2 connector or the clutch position sensor connector are not making	Clutch Position Sensor."	Connectors and/or pins are damaged, soiled, worn, broken, or corroded. All connectors and pins are OK.	Replace the damaged components. Go to the next row in the table.			
good contact. The clutch position sensor is not	Remove the clutch position sensor wiring. Check for resistance	The resistance is less than 35.8 or greater than 126.2 ohms.	Replace the clutch actuator. See Subject 120 .			
providing the correct resistance data.	between pins 1 and 2 of the sensor connector.	The resistance is between 35.8 and 126.2 ohms.	Go to the next row in the table.			
The transmission harness has an open circuit.	With the sensor wiring disconnected, remove the X2 connector from the TCU. Check for resistance on the female connectors from X2 connector plug 10 to sensor connector plug 2.	The circuit is open.	Replace the transmission harness. See Subject 180 .			
		There is measurable resistance of 0.5 to 1.5 ohms.	Go to the next resistance check.			
	With the transmission harness wiring disconnected, check for resistance on the female connectors from X2 connector plug 5 to sensor connector plug 1.	The circuit is open.	Replace the transmission harness. See Subject 180 .			
		There is measurable resistance of 0.5 to 1.5 ohms.	Go to the next row in the table.			

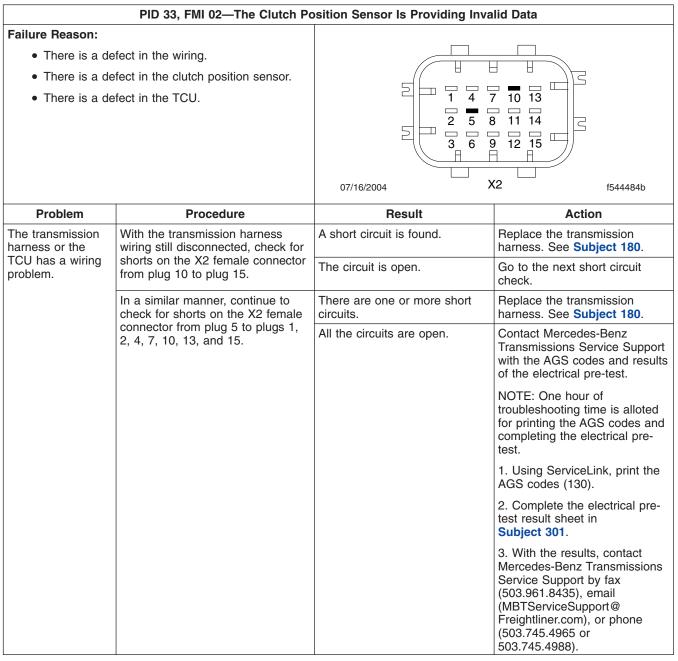


Table 1, The Clutch Position Sensor Is Providing Invalid Data

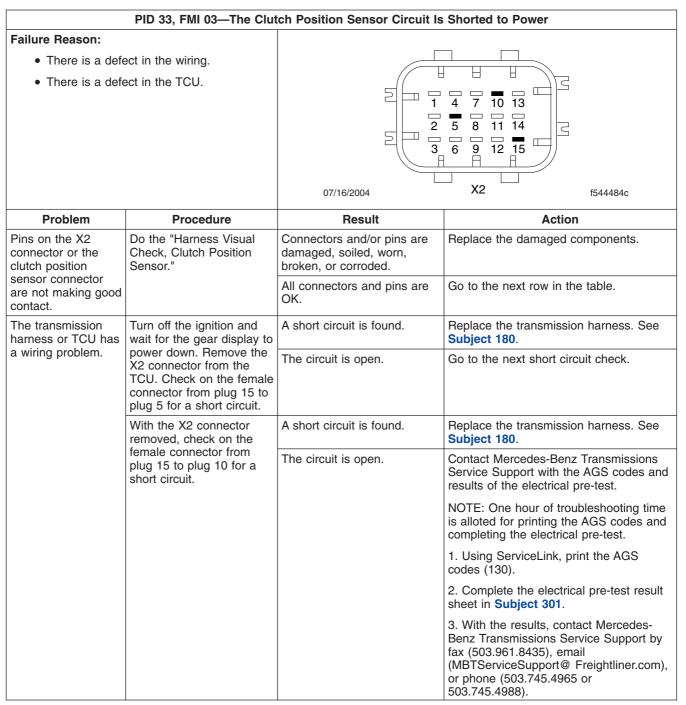


Table 2, The Clutch Position Sensor Circuit Is Shorted to Power

PID 33, FMI 04—The Clutch Position Sensor Circuit Is Shorted to Ground Failure Reason: • There is a defect in the wiring. • There is a defect in the clutch position sensor. • There is a defect in the TCU. 10 X2 07/16/2004 f544484b **Problem Procedure** Result Action Pins on the X2 Do the "Harness Visual Check, Replace the damaged Connectors and/or pins are connector or the clutch Clutch Position Sensor." components. damaged, soiled, worn, broken, position sensor or corroded. connector are not All connectors and pins are OK. Go to the next row in the table. making good contact. The clutch position Remove the clutch position The resistance is less than 35.8 Replace the clutch actuator. sensor is not providing sensor wiring. Check for See Subject 120. or greater than 126.2 ohms. the correct resistance resistance between pins 1 and The resistance is between 35.8 Go to the next row in the table. 2 of the sensor connector. data. and 126.2 ohms.

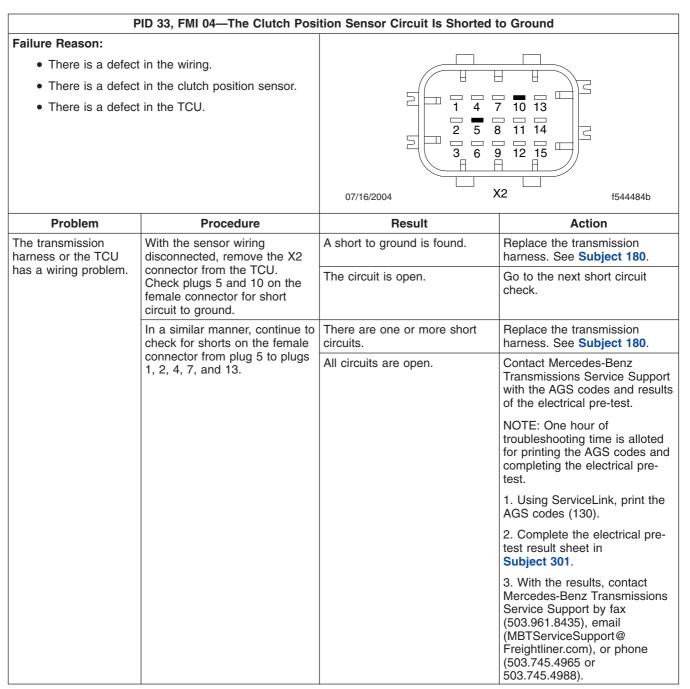


Table 3, The Clutch Position Sensor Circuit Is Shorted to Ground

PID 33, FMI 05—The Clutch Position Sensor Circuit Is Open				
Failure Reason: There is a defect in the wiring. There is a defect in the clutch position sensor. There is a defect in the TCU.		Ch Position Sensor Circuit Is Open 1 4 7 10 13 2 5 8 11 14 3 6 9 12 15 9 77/16/2004 X2 f544484b		
Problem	Procedure	Result	Action	
Pins on the X2 connector or the clutch position sensor connector are not	Do the "Harness Visual Check, Clutch Position Sensor."	Connectors and/or pins are damaged, soiled, worn, broken, or corroded. Replace the damaged components.		
making good contact.		All connectors and pins are OK.	Go to the next row in the table.	
The clutch position sensor is not	Remove the clutch position sensor wiring. Check for resistance between pins 1 and 2 of the sensor connector.	The resistance is less than 35.8 or greater than 126.2 ohms.	Replace the clutch actuator. See Subject 120 .	
providing the correct resistance data.		The resistance is between 35.8 and 126.2 ohms.	Go to the next row in the table.	

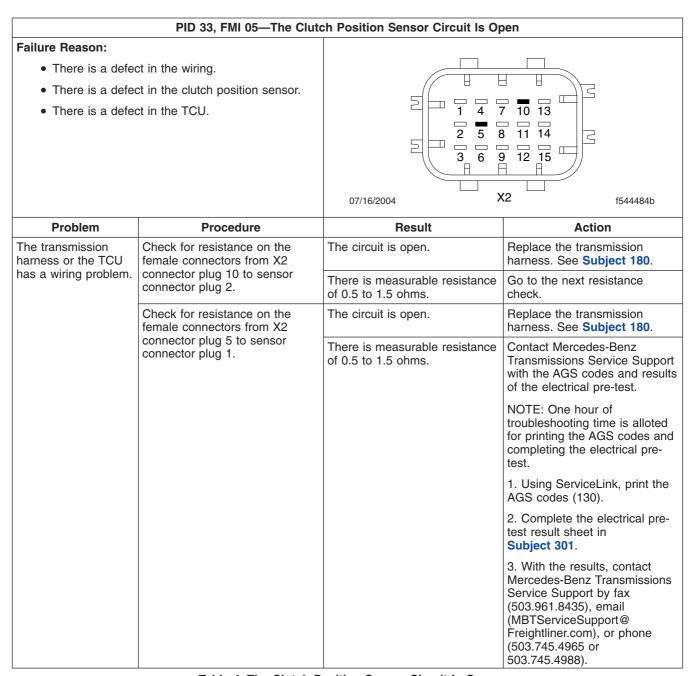


Table 4, The Clutch Position Sensor Circuit Is Open

PID 33, FMI 14—The Clutch Position Sensor Gives Incorrect Resistance Readings Failure Reason: • The resistance values broadcast on the datalink are not plausible. • There is a defect in the wiring. 10 There is a defect in the clutch position sensor. • There is a defect in the TCU. X2 07/16/2004 f544484b **Problem Procedure** Result Action Pins on the X2 Do the "Harness Visual Check, Connectors and/or pins are Replace the damaged connector or the clutch Clutch Position Sensor." damaged, soiled, worn, broken, components. or corroded. position sensor connector are not Go to the next row in the table. All connectors and pins are OK. making good contact. The clutch position Disconnect the rail position The resistance is less than 35.8 Replace the clutch actuator. sensor is not providing sensor wiring. Check for See Subject 120. or greater than 126.2 ohms. the correct resistance resistance between pins 1 and The resistance is between 35.8 Contact Mercedes-Benz 2 of the sensor connector. data. and 126.2 ohms. Transmissions Service Support with the AGS codes and results of the electrical pre-test. NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pretest. 1. Using ServiceLink, print the AGS codes (130). 2. Complete the electrical pretest result sheet in Subject 301. 3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).

Table 5, The Clutch Position Sensor Gives Incorrect Resistance Readings

Harness Visual Check, Clutch Position Sensor

- Remove the X2 female connector from the TCU. Check the plugs on the connector. If any plug(s) in the connector is damaged, soiled, worn, broken, or corroded, replace the connector. If no female connectors are available, replace the transmission wiring harness. See Subject 180 for procedures.
- Check the pins on the X2 male connector. If any pin(s) on the connector is damaged, soiled, worn, broken, or corroded, replace the TCU. See Subject 110 for procedures.
- Remove the female connector from the clutch position sensor. If any plug(s) in the connector is damaged, soiled, worn, broken, or corroded, replace the connector. If no female connectors are available, replace the transmission wiring harness. See Subject 180 for procedures.
- Check the pins on the male connector of the clutch position sensor. If any pin(s) on the connector is damaged, soiled, worn, broken, or corroded, replace the clutch actuator assembly. See Subject 120 for procedures.

Gear Position Sensor Faults

There are five gear position sensor faults covered in these procedures. Each one requires a separate electrical test.

- For PID 59, FMI 02, see **Table 1** for procedures and pin identification.
- For PID 59, FMI 03, see **Table 2** for procedures and pin identification.

- For PID 59, FMI 04, see **Table 3** for procedures and pin identification.
- For PID 59, FMI 05, see **Table 4** for procedures and pin identification.
- For PID 59, FMI 14, see **Table 5** for procedures and pin identification.

PID 59, FMI 02—The Gear Position Sensor Is Providing Invalid Data					
Failure Reason: There is a defect in the wiring. There is a defect in the gear position sensor. There is a defect in the TCU.		07/16/2004 X2 f544484d			
Problem	Procedure	Result		Action	
Pins on the X2 connector or the gear position sensor Do the "Harness Visual Check, Gear Position Sensor."		Connectors and/or pins are damaged, soiled, worn, broor corroded.		eplace the damaged omponents.	
connector are not making good contact.		All connectors and pins are	e OK. Go	o to the next row in the table.	

	PID 59, FMI 02—The Gear Pos	sition Sensor Is Providing Inval	id Data
Failure Reason: • There is a defect in the wiring. • There is a defect in the gear position sensor. • There is a defect in the TCU.		07/16/2004 X2 f544484d	
Problem	Procedure	Result	Action
The gear position sensor is not providing the correct resistance data.	Disconnect the gear position sensor wiring. Check for resistance between pins 1 and 2 of the gear position sensor connector.	The resistance is less than 34 or greater than 122 ohms.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test. NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre- test. 1. Using ServiceLink, print the AGS codes (130). 2. Complete the electrical pre- test result sheet in Subject 301. 3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).
		The resistance is between 34 and 122 ohms.	The sensor is OK. Go to the next row in the table.

PID 59, FMI 02—The Gear Position Sensor Is Providing Invalid Data				
PID 59, FMI 02—The Gear Post Failure Reason: There is a defect in the wiring. There is a defect in the gear position sensor. There is a defect in the TCU.		1 4 7 10 13 2 5 8 11 14 3 6 9 12 15		
Problem	Procedure	07/16/2004 /	Action	
The transmission harness has an open circuit.	With the sensor wiring disconnected, remove the X2 connector from the TCU. Check for resistance on the female connectors from X2 connector plug 7 to sensor connector plug 2.	The circuit is open.	Replace the transmission harness. See Subject 180.	
		There is measurable resistance of 0.5 to 1.5 ohms.	Go to the next resistance check.	
	With the transmission harness wiring disconnected, check for resistance on the female connectors from X2 connector plug 3 to sensor connector plug 1.	The circuit is open.	Replace the transmission harness. See Subject 180 .	
		There is measurable resistance of 0.5 to 1.5 ohms.	Go to the next row in the table.	

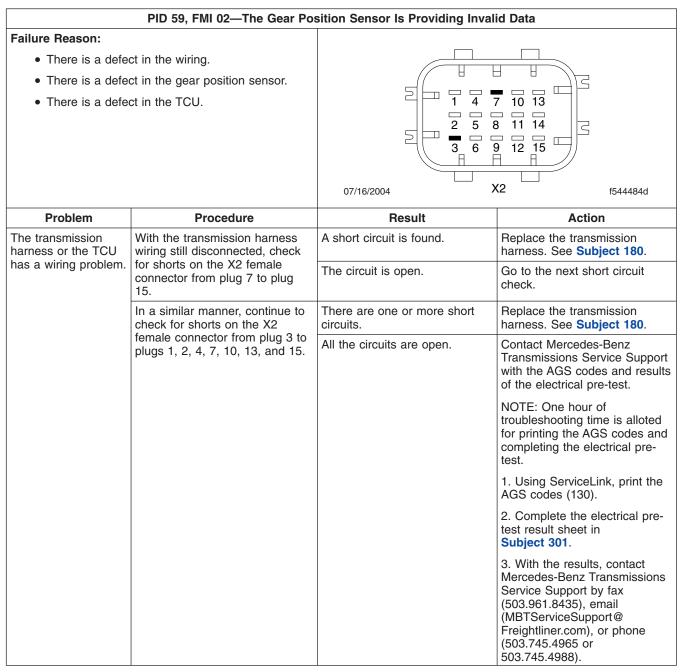
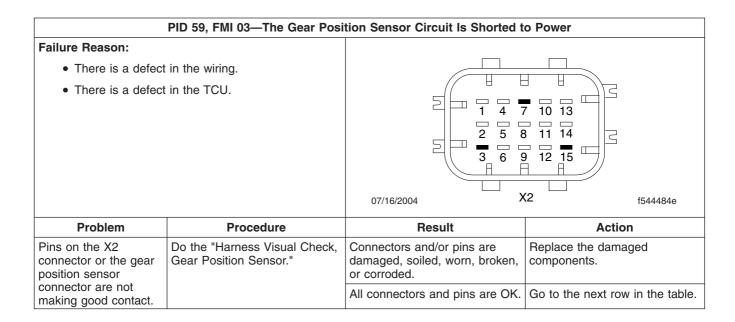


Table 1, The Gear Position Sensor Is Providing Invalid Data



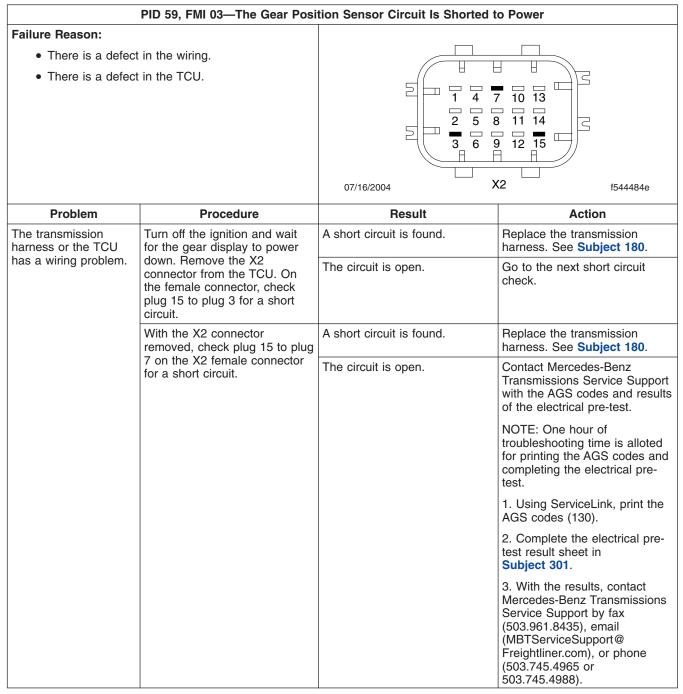


Table 2, The Gear Position Sensor Circuit Is Shorted to Power

PID 59, FMI 04—The Gear Position Sensor Circuit Is Shorted to Ground Failure Reason: • There is a defect in the wiring. • There is a defect in the gear position sensor. • There is a defect in the TCU. 10 Χ2 07/16/2004 f544484f **Problem Procedure** Result **Action** Pins on the X2 Do the "Harness Visual Check, Connectors and/or pins are Replace the damaged connector or the gear Gear Position Sensor." damaged, soiled, worn, broken, components. position sensor or corroded. connector are not All connectors and pins are OK. Go to the next row in the table. making good contact. The gear position Remove the gear position The resistance is less than 34 Replace the x-y actuator. See sensor is not providing sensor wiring. Check for or greater than 122 ohms. Subject 170. the correct resistance resistance between pins 1 and The resistance is between 34 Go the next row in the table. 2 of the sensor connector. data. and 122 ohms.

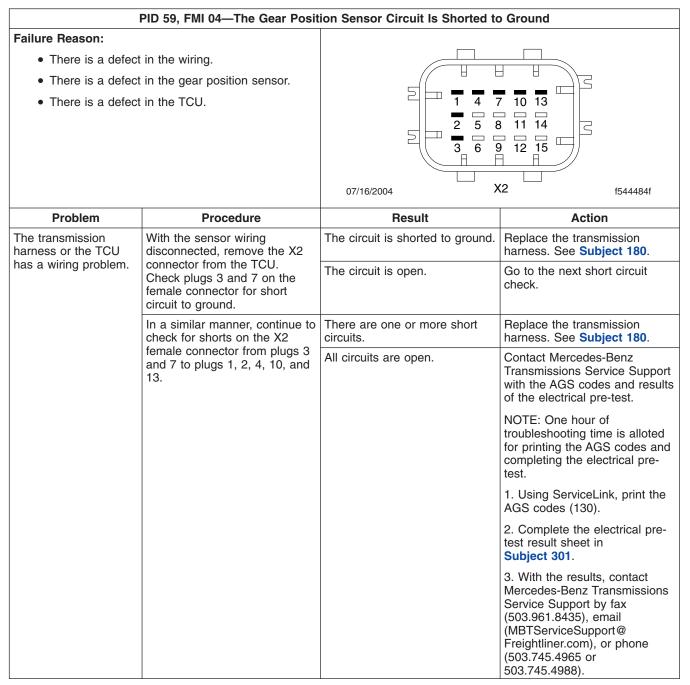
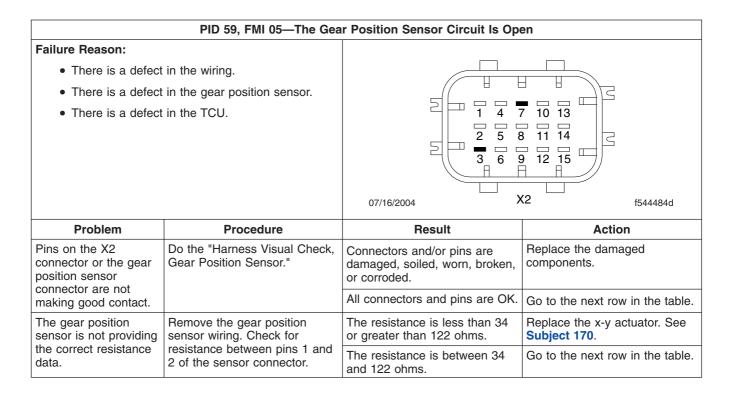


Table 3, The Gear Position Sensor Circuit Is Shorted to Ground



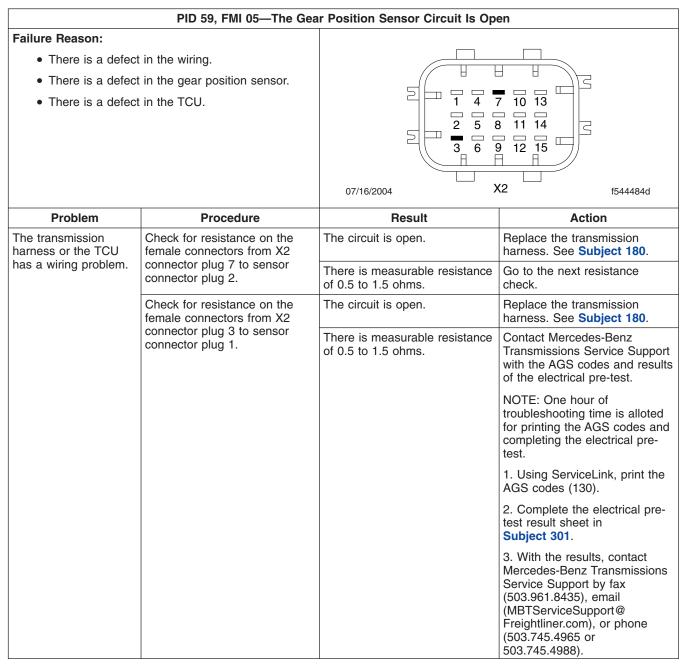


Table 4, The Gear Position Sensor Circuit Is Open

PID 59, FMI 14—The Gear Position Sensor Gives Incorrect Resistance Readings

Failure Reason:

- The resistance values broadcast on the datalink are not plausible.
- There is a defect in the wiring.
- There is a defect in the gear position sensor.
- There is a defect in the TCU.

Problem	Procedure	Result	Action	
Pins on the X2 connector or the gear position sensor	Do the "Harness Visual Check, Gear Position Sensor."	Connectors and/or pins are damaged, soiled, worn, broken, or corroded.	Replace the damaged components.	
connector are not making good contact.		All connectors and pins are OK.	Go to the next row in the table.	
The gear position sensor is not	Disconnect the gear position sensor wiring. Check for	The resistance is less than 34 or greater than 122 ohms.	Replace the x-y actuator. See Subject 170 .	
providing the correct resistance data.	of the sensor connector			Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.
			NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pretest.	
			1. Using ServiceLink, print the AGS codes (130).	
			2. Complete the electrical pretest result sheet in Subject 301.	
			3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).	

Table 5, The Gear Position Sensor Gives Incorrect Resistance Readings

Harness Visual Check, Gear Position Sensor

- Remove the X2 female connector from the TCU. Check the plugs on the connector. If any plug(s) in the connector is damaged, soiled, worn, broken, or corroded, replace the connector. If no female connectors are available, replace the
- transmission wiring harness. See **Subject 180** for procedures.
- Check the pins on the X2 male connector. If any pin(s) on the connector is damaged, soiled, worn, broken, or corroded, replace the TCU. See Subject 110 for procedures.
- 3. Remove the female connector from the gear position sensor. If any plug(s) in the connector is

damaged, soiled, worn, broken, or corroded, replace the connector. If no female connectors are available, replace the transmission wiring harness. See **Subject 180** for procedures.

 Check the pins on the male connector of the gear position sensor. If any pin(s) on the connector is damaged, soiled, worn, broken, or corroded, replace the x-y actuator assembly. See Subject 170 for procedures.

Rail Position Sensor Faults

There are five rail position sensor faults covered in these procedures. Each one requires a separate electrical test.

- For PID 60, FMI 02, see Table 1 for procedures and pin identification.
- For PID 60, FMI 03, see **Table 2** for procedures and pin identification.

- For PID 60, FMI 04, see **Table 3** for procedures and pin identification.
- For PID 60, FMI 05, see **Table 4** for procedures and pin identification.
- For PID 60, FMI 14, see **Table 5** for procedures and pin identification.

	PID 60, FMI 02—The Rail Pos	ition Sensor Is Providing Inval	id Data	
Failure Reason:		<u> </u>		
There is a defect in the wiring.				
There is a defect	ct in the rail position sensor.			
There is a defect in the TCU.		5 I I I I I I I I I I I I I I I I I I I	7 10 13 8 11 14 9 12 15	
		07/16/2004	X2 f544484g	
Problem	Procedure	Result	Action	
Pins on the X2 connector or the rail position sensor	Do the "Harness Visual Check, Rail Position Sensor."	Connectors and/or pins are damaged, soiled, worn, broken, or corroded.	Replace the damaged components.	
connector are not making good contact.		All connectors and pins are OK.	Go to the next row in the table.	
The rail position sensor is not	Disconnect the rail position sensor wiring. Check for	The resistance is less than 34 or greater than 122 ohms.	Replace the x-y actuator. See Subject 170 .	
providing the correct resistance data.	resistance between pins 1 and 2 of the rail position sensor connector.	The resistance is between 34 and 122 ohms.	Go to the next row in the table.	
The transmission harness has an open	With the sensor wiring disconnected, remove the X2	The circuit is open.	Replace the transmission harness. See Subject 180 .	
circuit.	connector from the TCU. Check for resistance on the female connectors from X2 connector plug 6 to sensor connector plug 1.	There is measurable resistance of 0.5 to 1.5 ohms.	Go to the next resistance check.	
	With the transmission harness wiring disconnected, check for	The circuit is open.	Replace the transmission harness. See Subject 180 .	
	resistance on the female connectors from X2 connector plug 2 to sensor connector plug 2.	There is measurable resistance of 0.5 to 1.5 ohms.	Go to the next row in the table.	

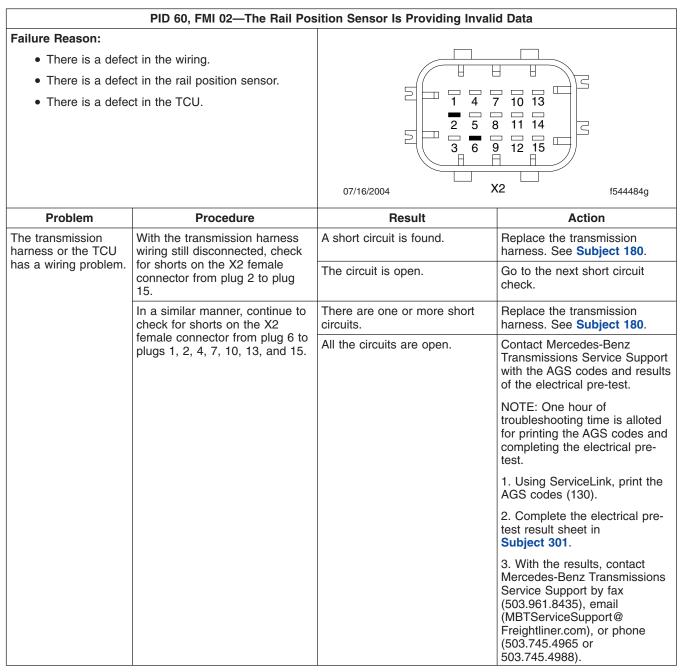
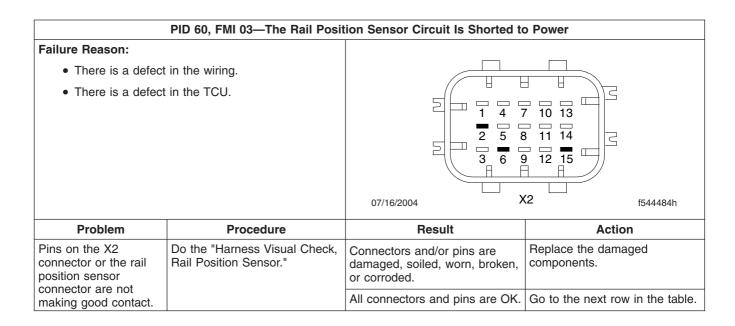


Table 1, The Rail Position Sensor Is Providing Invalid Data



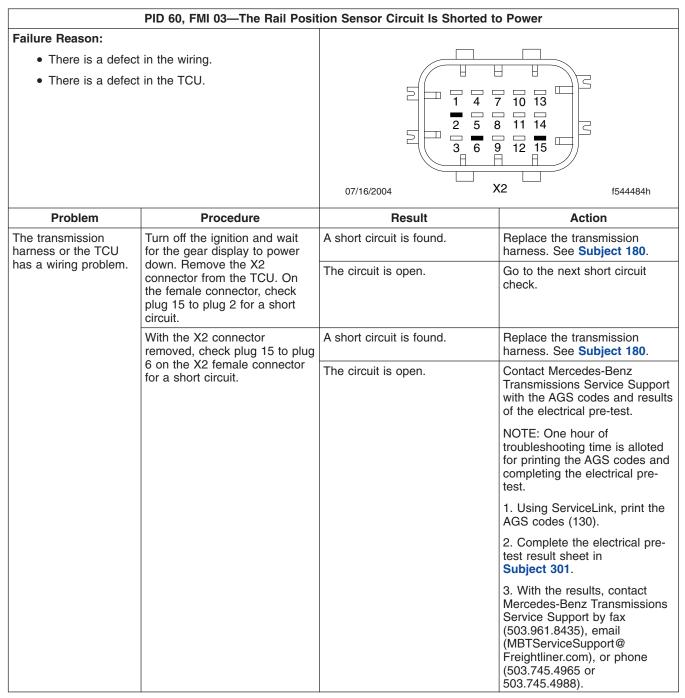


Table 2, The Rail Position Sensor Circuit Is Shorted to Power

	PID 60, FMI 04—The Rail Positi	on Sensor Circuit Is Shorted to	Ground
Failure Reason: There is a defect in the wiring. There is a defect in the rail position sensor. There is a defect in the TCU.		3 6 9	
Problem	Procedure	Result	Action
Pins on the X2 connector or the rail position sensor	Do the "Harness Visual Check, Rail Position Sensor."	Connectors and/or pins are damaged, soiled, worn, broken, or corroded.	Replace the damaged components.
connector are not making good contact.		All connectors and pins are OK.	Go to the next row in the table.
The rail position sensor is not providing the correct resistance data.	Remove the rail position sensor wiring. Check for resistance between pins 1 and 2 of the sensor connector.	The resistance is less than 34 or greater than 122 ohms.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test. NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre- test. 1. Using ServiceLink, print the AGS codes (130). 2. Complete the electrical pre- test result sheet in Subject 301. 3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4968).
		The resistance is between 34 and 122 ohms.	Go to the next row in the table.

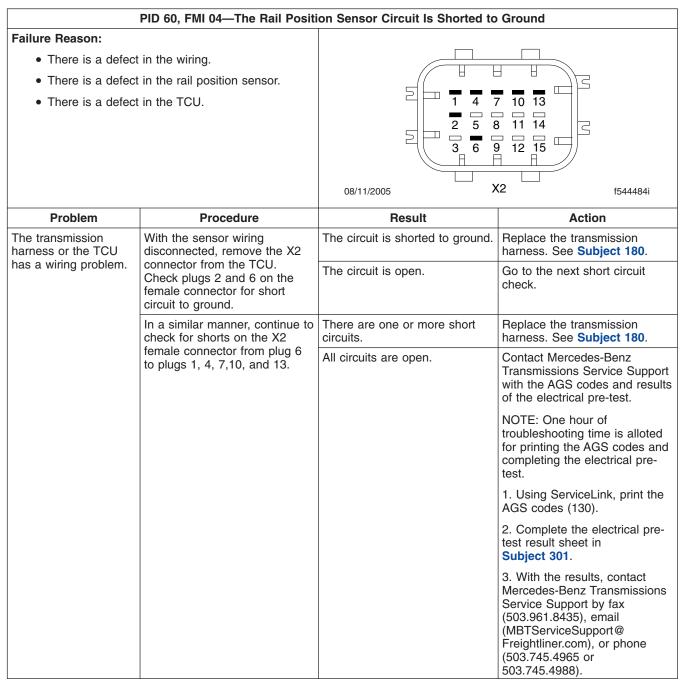


Table 3, The Rail Position Sensor Circuit Is Shorted to Ground

	PID 60, FMI 05—The Rai	I Position Sensor Circuit Is Ope	en
Failure Reason: There is a defect in the wiring. There is a defect in the rail position sensor. There is a defect in the TCU.		3 6 9	7 10 13 3 11 14 9 12 15 62 f544484g
Problem	Procedure	Result	Action
Pins on the X2 connector or the rail position sensor	Do the "Harness Visual Check, Rail Position Sensor."	Connectors and/or pins are damaged, soiled, worn, broken, or corroded.	Replace the damaged components.
connector are not making good contact.		All connectors and pins are OK.	Go to the next row in the table.
The rail position sensor is not providing the correct resistance data.	Remove the rail position sensor wiring. Check for resistance between pins 1 and 2 of the sensor connector.	The resistance is less than 34 or greater than 122 ohms.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test. NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre- test. 1. Using ServiceLink, print the AGS codes (130). 2. Complete the electrical pre- test result sheet in Subject 301. 3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).
		The resistance is between 34 and 122 ohms.	Go to the next row in the table.

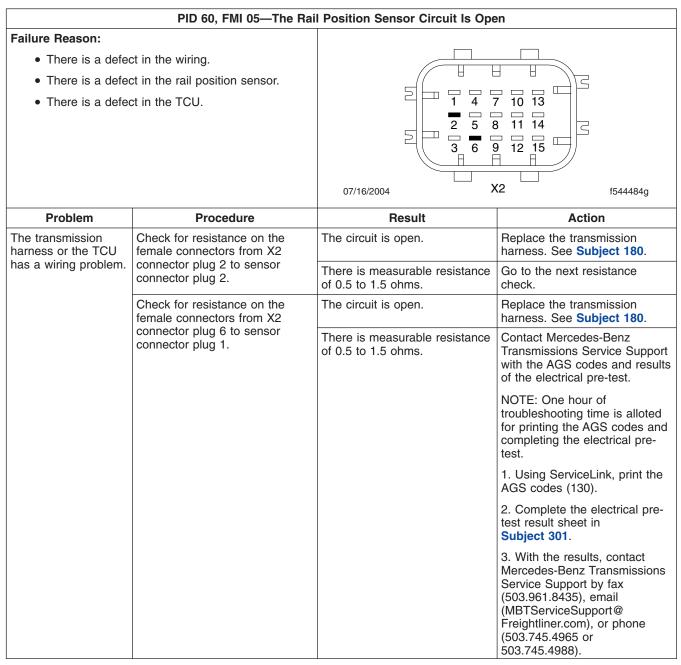


Table 4, The Rail Position Sensor Circuit Is Open

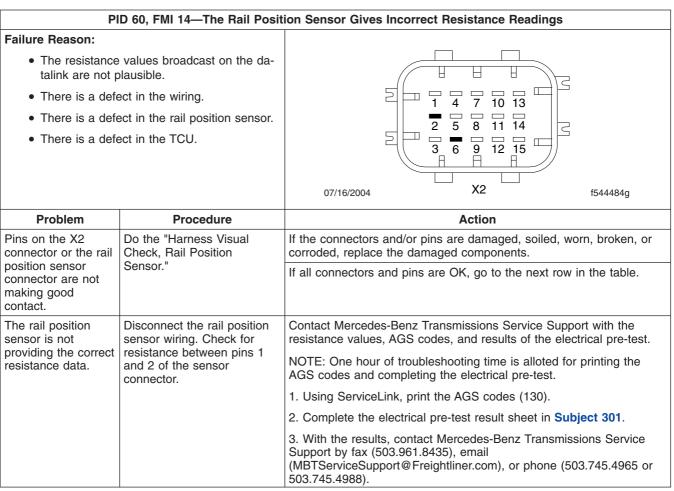


Table 5, The Rail Position Sensor Gives Incorrect Resistance Readings

Harness Visual Check, Rail Position Sensor

- Remove the X2 female connector from the TCU. Check the plugs on the connector. If any plug(s) in the connector is damaged, soiled, worn, broken, or corroded, replace the connector. If no female connectors are available, replace the transmission wiring harness. See Subject 180 for procedures.
- Check the pins on the X2 male connector. If any pin(s) on the connector is damaged, soiled, worn, broken, or corroded, replace the TCU. See Subject 110 for procedures.
- 3. Remove the female connector from the rail position sensor. If any plug(s) in the connector is damaged, soiled, worn, broken, or corroded, replace the connector. If no female connectors are available, replace the transmission wiring harness. See **Subject 180** for procedures.
- Check the pins on the male connector of the rail position sensor. If any pin(s) on the connector is damaged, soiled, worn, broken, or corroded, replace the x-y actuator assembly. See Subject 170 for procedures.

Vehicle Direction Signal Faults

There are two vehicle direction signal faults covered in these procedures. There is one procedure to correct both faults.

- For PID 64, FMI 09, see Table 1 for procedures.
- For PID 64, FMI 11, see Table 1 for procedures.

PID 6	64, FMI 09, 11—The Output Shaft S	peed Sensor Is Not Providing	Accurate Data
Failure Reason:			
 There is a defect in one or both of the output shaft speed sensors. 			
There is a defect	ct in the wiring.	□ □ □ □ □ □ □ □ □ □ □	7 10 13
There is a defect in the TCU.		2 5 8	8 11 14 9 12 15
		07/16/2004	K2 f544484k
Problem	Procedure	Result	Action
One or both of the sensors is damaged	Do a visual check of both speed sensors.	A sensor is damaged or broken.	Replace the affected sensor. See Subject 120 .
or broken.		Both sensors are OK.	Go to the next row in the table.
One or both of the sensors is loose.			Tighten the affected sensor 28 lbf·ft (38 N·m).
		Both sensors are firmly attached and tightened to the correct specifications.	Go to the next row in the table.
One or both of the sensors has a wiring	Check the sensor wiring.	A sensor is wired wrong.	Wire the affected sensor correctly.
problem.		Both sensors are wired correctly.	Go to the next row in the table.
Pins on the X2 connector are not making good contact.	connector are not harness from the X2 connector. Do		Replace the damaged components.
halves (both male and female).		All connectors and pins are OK.	Go to the next row in the table.
Pins on the output shaft speed sensor connectors are not	Disconnect the transmission harness from the two sensor connectors. Do a visual check of	Connectors and/or pins are damaged, soiled, worn, broken, or corroded.	Replace the damaged components.
making good contact. both sensor connector halves (bot male and female).		All connectors and pins are OK.	Go to the next row in the table.

PID 64, FMI 09, 11—The Output Shaft Speed Sensor Is Not Providing Accurate Data Failure Reason: • There is a defect in one or both of the output shaft speed sensors. • There is a defect in the wiring. 10 13 • There is a defect in the TCU. X2 07/16/2004 f544484k **Problem Procedure** Result **Action** The wiring of the #1 With the sensor wiring still The circuit is open. Replace the transmission disconnected, check for resistance harness. See Subject 180. output shaft speed on the female connectors from X2 sensor (at the 11:00 There is measurable Go to the next resistance position) has an open connector plug 1 to output shaft resistance of 0.5 to 1.5 ohms. check. speed sensor #1 connector plug 2. circuit. Replace the transmission Check for resistance on the female The circuit is open. connectors from X2 connector plug harness. See Subject 180. 15 to output shaft speed sensor #1 There is measurable Go to the next resistance connector plug 1. resistance of 0.5 to 1.5 ohms. check. Check for resistance on the female The circuit is open. Replace the transmission connectors from X2 connector plug harness. See Subject 180. 14 to output shaft speed sensor #1 There is measurable Go to the next row in the connector plug 4. resistance of 0.5 to 1.5 ohms. table. The wiring of the #2 With the sensor wiring still Replace the transmission The circuit is open. output shaft speed disconnected, check for resistance harness. See Subject 180. sensor (at the 9:00 on the female connectors from X2 There is measurable Go to the next resistance position) has an open connector plug 1 to output shaft resistance of 0.5 to 1.5 ohms. check. speed sensor #2 connector plug 2. circuit. Check for resistance on the female The circuit is open. Replace the transmission harness. See Subject 180. connectors from X2 connector plug 15 to output shaft speed sensor #2 There is measurable Go to the next resistance connector plug 1. resistance of 0.5 to 1.5 ohms. check. Check for resistance on the female Replace the transmission The circuit is open. connectors from X2 connector plug harness. See Subject 180. 9 to output shaft speed sensor #2 There is measurable Go to the next row in the connector plug 3. resistance of 0.5 to 1.5 ohms. table.

PID 64, FMI 09, 11—The Output Shaft Speed Sensor Is Not Providing Accurate Data Failure Reason: • There is a defect in one or both of the output shaft speed sensors. 10 13 • There is a defect in the wiring. • There is a defect in the TCU. X2 07/16/2004 f544484k **Problem Procedure** Result **Action** There is a short With the sensor wiring still There are one or more short Replace the transmission disconnected, check for a short harness. See Subject 180. circuit in the output circuits. shaft speed sensor circuit on the female connectors All circuits are open. Go to the next short circuit wiring. from X2 connector plug 1 to X2 check. connector plugs 3, 5, 6, 9, 11, 12, 14. and 15. Check for a short circuit on the There are one or more short Replace the transmission female connectors from X2 harness. See Subject 180. circuits. connector plug 9 to X2 connector All circuits are open. Go to the next short circuit plugs 2, 3, 4, 5, 6, 7, 10, 11, 12, check. and 13. Check for a short circuit on the Replace the transmission There are one or more short circuits. harness. See Subject 180. female connectors from X2 connector plug 14 to X2 connector Go to the next short circuit All circuits are open. plugs 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, check. and 13. Check for a short circuit on the Replace the transmission There are one or more short female connectors from X2 harness. See Subject 180. circuits. connector plug 15 to X2 connector Go to the next row in the All circuits are open. plugs 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, table. 13, and 14.

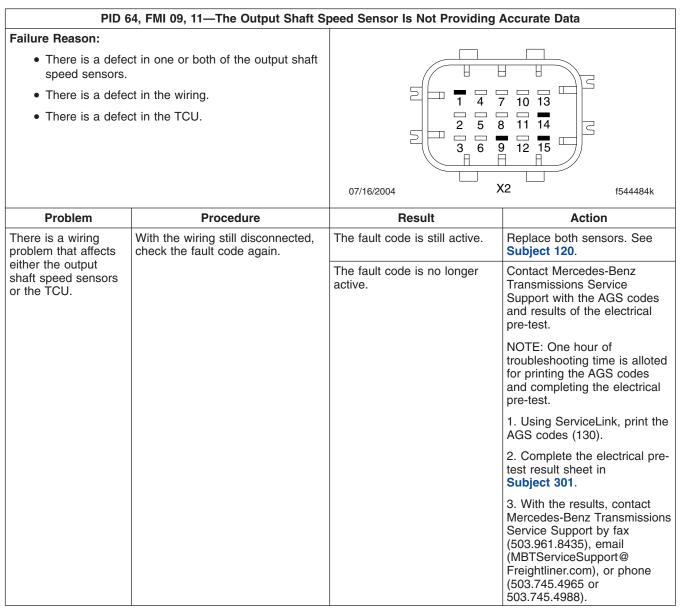


Table 1, The Output Shaft Speed Sensor Is Not Providing Accurate Data

Ignition Power Supply Faults (PID 158)

Ignition Power Supply Faults

There are two ignition power circuit faults covered in these procedures. Each one requires a different electrical test.

- For PID 158, FMI 00, see **Table 1** for procedures and pin identification.
- For PID 158, FMI 01, see **Table 2** for procedures and pin identification.

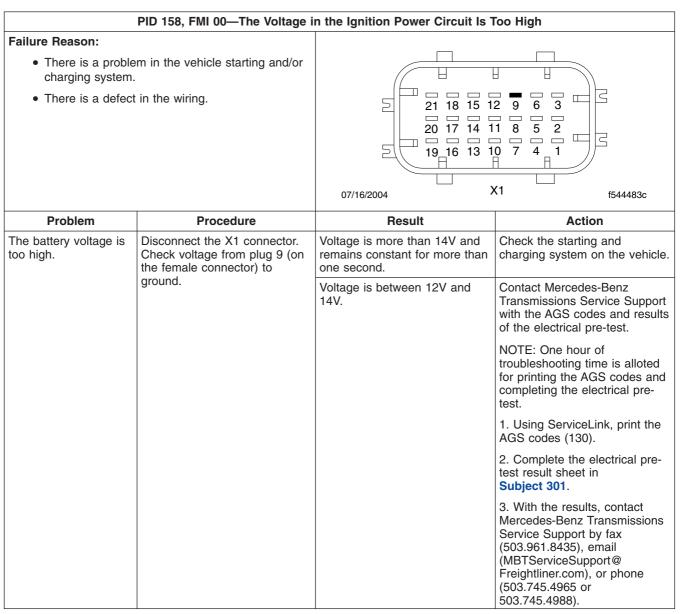


Table 1, The Voltage in the Ignition Power Circuit Is Too High

Ignition Power Supply Faults (PID 158)

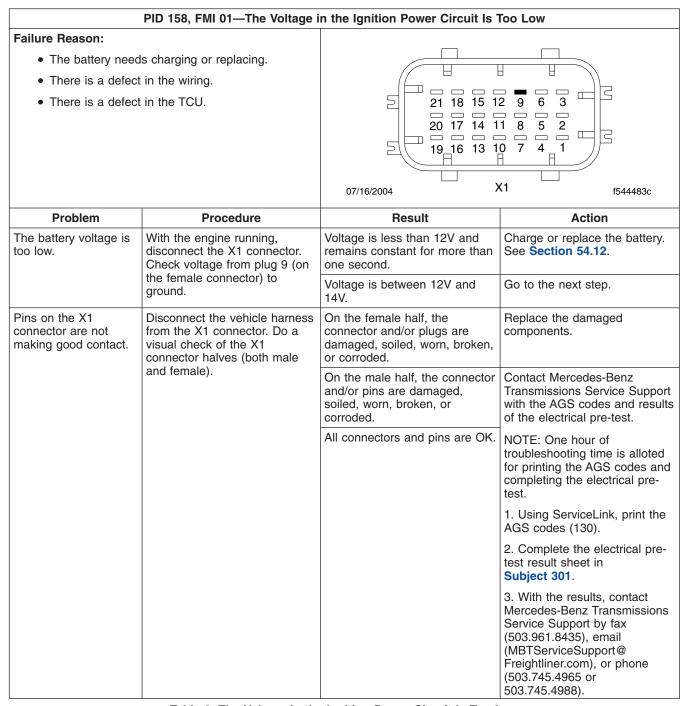


Table 2, The Voltage in the Ignition Power Circuit Is Too Low

Input Shaft Speed Sensor Faults (PID 161)

Input Shaft Speed Sensor Faults

There are five input shaft speed sensor faults covered in these procedures. One troubleshooting procedure is used to correct FMI 02, 03, 04, and 05. A separate procedure is used for FMI 08.

- For PID 161, FMI 02, 03, 04, and 05, see
 Table 1 for procedures.
- For PID 161, FMI 08, see Table 2 for procedures.

PID 161, FMI 02, 03, 04, 05—The Input Shaft Speed Sensor Circuit Gives Invalid Data, Is Shorted, or Open				
Failure Reason				
There is a defect in the input shaft speed sensor.	Tre			
There is a defect in the wiring.				
There is a defect in the TCU.				
The resistance values broadcast on the datalink are not plausible.				
	07/16/2004	X2 f544484j		
Procedure	Result	Action		
Turn off the ignition switch and wait for the current gear display to power down. Remove the X2 connector from the TCU. At room temperature, measure the resistance	Resistance is less than 900 or more than 1200 ohms.	Go to the next row in the table and check for a defective sensor.		
between pins 11 and 13.	Resistance is between 900 and 1200 ohms.	Go to the bottom row in the table and check for a defective wiring harness or TCU.		
Unlock the connector cap from the sensor. At room temperature, measure the resistance between the two pins	Resistance is less than 900 or more than 1200 ohms.	Replace the input shaft speed sensor (see Subject 120).		
of the sensor.	Resistance is between 900 and 1200 ohms.	Go to the bottom row in the table.		

Input Shaft Speed Sensor Faults (PID 161)

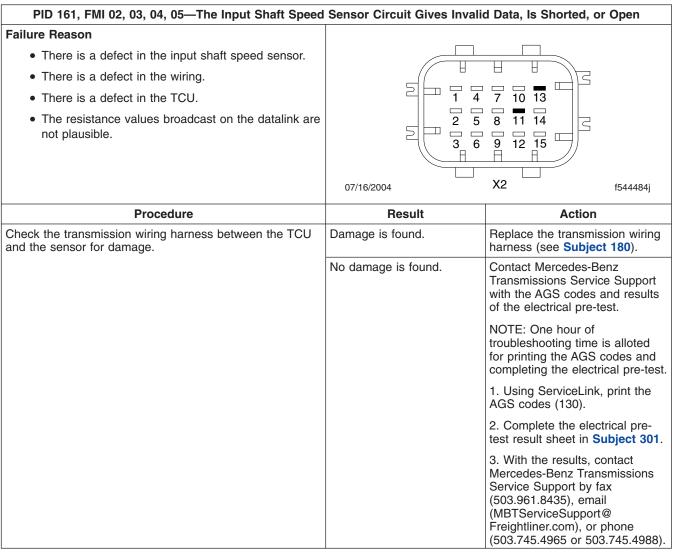


Table 1, The Input Shaft Speed Sensor Circuit Gives Invalid Data, Is Shorted, or Open

Input Shaft Speed Sensor Faults (PID 161)

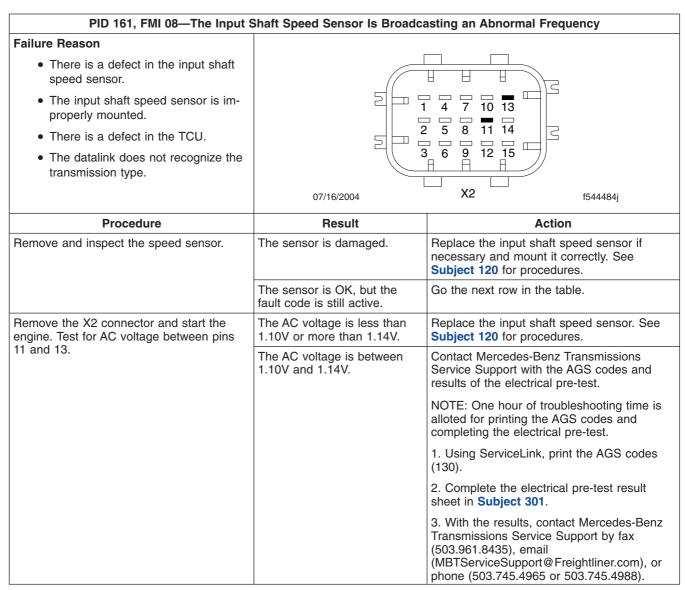


Table 2, The Input Shaft Speed Sensor Is Broadcasting an Abnormal Frequency

Transmission Range Faults (PID 162 and 163)

Transmission Range Faults

Transmission Range-Selected Faults (PID 162)

There is one transmission range-selected fault covered in these procedures.

For PID 162, FMI 02, see Table 1 for procedures.

Transmission Range-Attained Faults (PID 163)

There is one transmission range-attained fault covered in these procedures.

For PID 163, FMI 02, see Table 2 for procedures.

PID 162, FMI 02—The Transmission Is Not Properly Calibrated				
Failure Reason:				
• The gears are	e caught in an intermediate position.			
 The transmiss 	sion software does not allow shifting.			
Problem	Procedure	Result	Action	
There are other active transmission faults.	Check for other MID 130 fault codes.	Other fault codes are active.	Troubleshoot the other active fault codes.	
		No other fault codes are active.	Go to the next step in the table.	
The transmission needs to be		The fault is no longer active.	No further action is needed.	
recalibrated.	To complete a learning procedure using the SmartShift control:	The fault is still active.	Contact Freightliner	
	1. Ensure that the parking brake is set.		Technical Service Support.	
	2. With the ignition turned off, pull and hold the SmartShift control toward steering wheel.			
	NOTE: The SmartShift control must be kept in this position until the gear display clears at the end of the procedure.			
	3. Turn on the ignition. The normal warm up procedure will initiate and an 'X' will display on the current gear indicator. Your transmission may be heard shifting.			
	4. Wait until the current gear indicator displays an 'N'			

Table 1, The Transmission Is Not Properly Calibrated

(about 30 seconds) and an audible alert sounds. Start the

5. The engine will raise a few rpm, then fall back to idle, and an audible alert will sound. Turn off the engine within 10 seconds of audible alert. When the gear display clears,

NOTE: If during this procedure an 'SM' or 'X' (after the warm up procedure) appears in the gear display, stop, turn off the ignition, and wait for the gear display to go dark. Then start over. This may need to be repeated several

engine within 10 seconds of the audible alert.

this procedure is complete.

times.

Transmission Range Faults (PID 162 and 163)

PID 163, FMI 02—The Gears Do Not Shift Properly

Failure Reason:

- There is a defect in the TCU.
- There is a defect in the speed sensor.
- There is a defect in the actuator.
- The transmission software is not properly programmed.
- The datalink does not recognize the transmission type.

Problem	Procedure	Result	Action	
There are other active transmission		Other fault codes are active.	Troubleshoot the other active fault codes.	
faults.		No other fault codes are active.	Go to the next step in the table.	
There is a transmission software problem.	Using the ServiceLink diagnostics template, view the different gear positions, check that the clutch opens and closes, and that the	The x-y actuator responds properly and the fault clears.	No further action is needed.	
	x-y actuator moves from reverse, 1st, and 2nd gears.	The fault is still active.	Go to the next step in the table.	
There is component damage in the	Do a visual inspection of the x-y actuator, the hydraulic system, and the transmission	Damaged components are found.	Contact Mercedes-Benz Transmissions Service	
transmission.	shift system.	No damaged components are found.	Support with the AGS codes and results of the electrical pre-test.	
			NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.	
			1. Using ServiceLink, print the AGS codes (130).	
				2. Complete the electrical pre-test result sheet in Subject 301 .
			3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@Freightliner.com), or phone (503.745.4965 or 503.745.4988).	

Table 2, The Gears Do Not Shift Properly

Output Shaft Speed Sensor Faults (PID 191)

Output Shaft Speed Sensor Faults (PID 191)

There are four output shaft speed sensor faults covered in these procedures. One troubleshooting procedure is used to correct FMI 02, 05, and 08. A separate procedure is used for FMI 14.

- For PID 191, FMI 02, 05, and 08 see **Table 1** for procedures and pin identification.
- For PID 191, FMI 14, see Table 2 for procedures.

PID 191, FMI 02, 05, 08—The Output Shaft Speed Sensor Circuit Gives Invalid Data, Is Open, or Not Broadcasting a Signal			
Failure Reason:			
 The TCU has a hardware problem. 			
 The sensor is mounted too loose (air gap too big). 	1 4 7 10 13		
 The sensor connectors are damaged or bent. 	2 5 3 6	8 11 14 S 9 12 15 S	
 The wiring harness has had an electrical failure. 			
 Either one of the sensors or the TCU has failed. 	07/16/2004	X2 f544484k	
Procedure	Results	Action	
Turn on the ignition switch and wait for the current gear display to power up.	Fault code SID 254, FMI 12 is active.	Go to Subject 309 and troubleshoot SID 254, FMI 12.	
	SID 254, FMI 12 is not active.	Go to the next row in the table.	
Remove both output shaft speed	The fault clears after a test drive. No further action needed.		
sensors. Reinstall and tighten the sensor 28 lbf-ft (38 N·m).	The fault remains active.	Go to the next row in the table.	
Turn off the ignition switch and wait for the current gear display to power down.	The connector pins are damaged or bent.	Repair or replace the damage.	
Remove both sensor connectors and visually inspect the pins.	There is no damage to either connector.	Go to the next row in the table.	
Check the upper sensor for continuity: (1) X2 connector pin 1 to sensor pin 2;	There is an open circuit.	Replace the transmission wiring harness (see Subject 180).	
(2) X2 connector pin 15 to sensor pin 1;(3) X2 connector pin 14 to sensor pin 4.	The wiring is OK.	Go to the next row in the table.	
Check the lower sensor for continuity: (1) X2 connector pin 1 to sensor pin 2;	There is an open circuit.	Replace the transmission wiring harness (see Subject 180).	
(2) X2 connector pin 15 to sensor pin 1;(3) X2 connector pin 9 to sensor pin 3.	The wiring is OK.	Go to the next row in the table.	
Check all four pins of each sensor connector for voltage and for continuity	Voltage or continuity is found.	Replace the transmission wiring harness (see Subject 180).	
to ground.	There is zero voltage and no continuity.	Go to the next row in the table.	

Output Shaft Speed Sensor Faults (PID 191)

PID 191, FMI 02, 05, 08—The Output Shaft Speed Sensor Circuit Gives Invalid Data, Is Open, or Not Broadcasting a Signal			
Failure Reason:			
 The TCU has a hardware prob- lem. 			
 The sensor is mounted too loose (air gap too big). 	1 4 7 10 13		
 The sensor connectors are damaged or bent. 		5 8 11 14 3	
 The wiring harness has had an electrical failure. 	3 6 9 12 15		
 Either one of the sensors or the TCU has failed. 	07/16/2004	X2 f544484k	
Procedure	Results	Action	
Using a sensor known to be good,	The fault becomes inactive.	No further action needed.	
replace each sensor in turn (see Subject 120 for procedures).	The fault is still active.	Contact Mercedes-Benz Transmissions Service Support with the AGS codes and results of the electrical pre-test.	
		NOTE: One hour of troubleshooting time is alloted for printing the AGS codes and completing the electrical pre-test.	
		1. Using ServiceLink, print the AGS codes (130).	
		2. Complete the electrical pre-test result sheet in Subject 301 .	
		3. With the results, contact Mercedes-Benz Transmissions Service Support by fax (503.961.8435), email (MBTServiceSupport@ Freightliner.com), or phone (503.745.4965 or 503.745.4988).	

Table 1, The Output Shaft Speed Sensor Circuit Gives Invalid Data, Is Open, or Not Broadcasting a Signal

PID 191, FMI 14—The Output Shaft Speed Sensor Is Providing Invalid Data		
Failure Reason		
• The antilock brake system (ABS) is not broa	dcasting wheel speed data.	
There is a defective output shaft speed sense.	sor.	
Procedure	Result	Action
Check for other PID 191 fault codes.	Other PID 191 fault codes are active.	Troubleshoot PID 191. See Table 1.
	No other PID 191 fault codes are active.	Go to the next step in the table.

Output Shaft Speed Sensor Faults (PID 191)

PID 191, FMI 14—The Output Sh	naft Speed Sensor Is Providing In	valid Data
Failure Reason		
 The antilock brake system (ABS) is not broadcas 	ting wheel speed data.	
There is a defective output shaft speed sensor.		
Procedure	Result	Action
Check for active fault codes in MID 136 (ABS).	Active MID 136 fault codes are found.	Troubleshoot the ABS system (see the applicable section in Group 42).

Table 2, The Output Shaft Speed Sensor Is Providing Invalid Data

For a schematic of the AGS transmission wiring behind the X2 (transmission) connector, see **Fig. 1**. For a schematic of the AGS transmission wiring behind the X1 (main vehicle) and X3 (electric motor) connectors, see drawing G06-49466.

For a list of special tools, see Table 1.

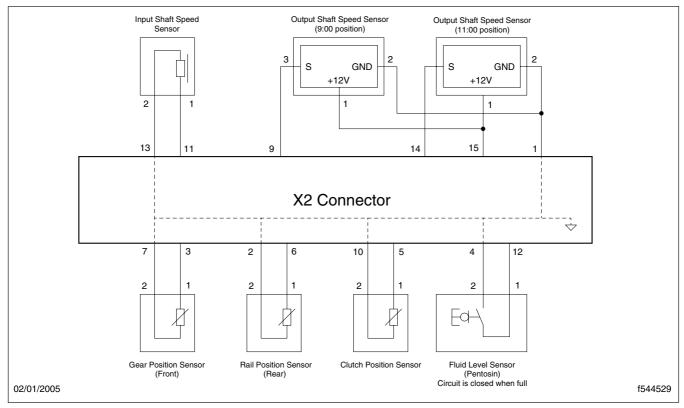


Fig. 1, AGS Transmission Wiring, X2 Connector

Special Tools for AGS Transmission			
Tool	Tool Description		Part Number
f580381	Accumulator Torque Adaptor	Kent-Moore	J-47291
f580379a	Low-Pressure Hose Disconnect Tool	Kent-Moore	J-47202

Special Tools for AGS Transmission			
Tool	Description	Manufacturer	Part Number
f580379	High-Pressure Line Disconnect Tool	Kent-Moore	J-47201
f580380	Shift Finger Alignment Fork	Kent-Moore	J-47204
1580382	Shift Mechanism End Guide	Kent-Moore	J-47203

Table 1, Special Tools for AGS Transmission

For transmission installation torque values, see **Table 2**.

Transmission Installation Torque Values			
Description	Size	Class	Torque: lbf·ft (N·m)
Midship Bearing Bracket Capscrews	3/4–11	_	91 (123)
Power Takeoff Unit (PTO) Mounting Capscrews	M10	10.9	43 (58)
Transmission Fluid Drain Plug	M24	_	42 (57)
Transmission Fluid Fill Plug	M24	_	42 (57)
Transmission Mounting Bolts	M10 x 1.5	8.8	33 (45)
II Joint End Con Bolto	3/8–24	_	50 (68)
U-Joint End Cap Bolts	1/2–20	_	110 (149)

Table 2, Transmission Installation Torque Values

For AGS assembly torque values, see Table 3.

AGS Assembly Torque Values			
Description Size Torque: lbf-ft (N-m) Torque: lbf-in (N-cm)			
Accumulator Hydraulic Fitting	M30	59 (80)	_
K-Y Actuator Mounting Capscrews M8 17 (23) —			

AGS Assembly Torque Values			
Description Size Torque: lbf·ft (N·m) Torque: lbf·in			
AGS Central Unit Mounting Capscrews	M8	17 (23)	_
Clutch Actuator Hydraulic Fittings	M30	37 (50)	_
Clutch Actuator Mounting Capscrews	M8	17 (23)	_
Pressure-Limiting Valve Adjusting Screw	M6	_	63–71 (700–800)
Reservoir Base Fasteners	M8	11 (15)	_
Reservoir Top Fasteners	M6	_	71 (800)
Rotational Speed (RPM) Sensors	_	28 (38)	_
Shift Rod Setscrew	M12	22 (30)	_
Transmission Control Unit (TCU) Mounting Screws	M8	_	44–53 (500–600)
TCU Splash Guard Mounting Capscrews	M8	17 (23)	_

Table 3, AGS Assembly Torque Values

For AGS transmission gear ratios, see Table 4.

AGS Transmission Gear Ratios		
Model	Gear	Ratio
	1	9.201
	2	5.230
	3	3.145
MBT520-6DA	4	2.034
	5	1.374
	6	1.000
	R	8.649
	1	6.700
	2	3.810
	3	2.290
MBT660-6OA	4	1.480
	5	1.000
	6	0.730
	R	6.290

Table 4, AGS Transmission Gear Ratios

For a list of proprietary fault codes viewable on ServiceLink, see **Table 5**.

	AGS Proprietary Fault Codes (J1708)
Fault Code Description	
3000109	High voltage supply voltage—external (connector X1/12 and X1/15)

	AGS Proprietary Fault Codes (J1708)
Fault Code	Description
3000113	High voltage ignition key line—external (connector X1/9)
3000209	Low voltage supply voltage—external (connector X1/12 and X1/15)
3000213	Low voltage ignition key line—external (connector X1/9)
3001210	EEPROM parameter values error—internal
3001510	Clutch displacement control module parameter error—internal
3001781	Clutch calibration offset off limit—internal
3002009	Open load supply voltage—external (connector X1/12 and X1/15)
3002016	Open load/Short circuit VCC temperature sensor circuit board—internal
3002017	Open load/Short circuit VCC temperature sensor pump—internal
3002116	Short circuit GND temperature sensor circuit board—internal
3002117	Short circuit GND temperature sensor pump—internal
3002214	Short circuit VCC peripherals supply—external (connector X2/15)
3003001	EBC1 message timeout—external (J1939)
3003101	EEC1 message timeout—external (J1939)
3003201	EEC2 message timeout—external (J1939)
3003301	EEC3 message timeout—external (J1939)
3003401	ERC1 message timeout—external (J1939)
3003501	Wheel speed information message timeout—external (J1939)
3003601	CruiseControl (VCU) message timeout—external (J1939)
3003701	CruiseControl (bulkhead) message timeout—external (J1939)
3003801	Engine configuration message timeout—external (J1939)
3003901	Retarder configuration message timeout—external (J1939)
3004001	Component identification message timeout—external (J1939)
3004101	PTO information message timeout—external (J1939)
3006101	Incorrect engine data—external (J1939)
3006201	Timeout converted engine data for clutch module (low priority)—internal
3006701	Incorrect retarder data—external (J1939)
3006801	Incorrect ABS data—external (J1939)
3006901	Incorrect internal data—internal
3007001	Incorrect clutch module data—internal
3007101	Incorrect automated gear shift module data—internal
3007201	Incorrect internal data—internal
3008881	Clutch overload—internal
3009280	Plausibility error actual transmission gear ratio—internal
3009710	Test software—internal
3009810	Test electronic—internal

Fault Code	AGS Proprietary Fault Codes (J1708)
3009910	Description Test bench mode activated—internal
3010390	Automatic module: signal group cruise control / retarder—internal
3010690	Automatic module: signal output speed—internal
3010790	Automatic module: signal group MR—internal
3010890	Automatic module: signal group gear ratio—internal
3010990	Automatic module: learning values engine—internal
3011081	Plausibility error intended clutch position can not be reached within specified time—internal
3011090	Automatic module: learning values transmission—internal
3011310	Clutch calibration data missing/error—internal
3011410	Clutch parameter error—internal
3011590	Automatic module: signal group shifting time—internal
3011690	Automatic module: signal group ABS—internal
3011790	Automatic module: signal group pedal activation—internal
3011890	Automatic module: signal group lever—internal
3011990	Automatic module: error target system—internal
3012014	Open load peripherals supply—external (connector X2/15)
3012019	Plausibility error valve relay V-V2 on—internal
3012035	Open load power stage solenoid valve (clutch open 1)—internal
3012036	Open load power stage solenoid valve (clutch open 2)—internal
3012037	Open load power stage solenoid valve (clutch close 1)—internal
3012038	Open load power stage solenoid valve (clutch close 2)—internal
3012050	Open load speed sensor transmission output (DZ1)—external (connector X2/14)
3012051	Open load speed sensor transmission input—external (connector X2/11)
3012052	Open load speed sensor transmission output (D3)—external (connector X2/9)
3012090	Automatic module: system identification gearshift module—internal
3012114	Short circuit to GND peripherals supply—external (connector X2/15)
3012118	Plausibility error valve relay V-V1 off—internal
3012119	Plausibility error valve relay V-V2 off—internal
3012136	Short circuit GND power stage solenoid valve (clutch open 2)—internal
3012138	Short circuit GND power stage solenoid valve (clutch close 2)—internal
3012151	Short circuit GND speed sensor transmission input—external (connector X2/11
3012251	Short circuit VCC speed sensor transmission input—external (connector X2/11)
3012461	Hydraulic level too low external—external
3016201	Timeout converted engine data for clutch module (medium priority)—internal
3016401	Timeout driving direction information—internal
3016501	Timeout internal communication shift module to clutch module (medium priority)—internal

	AGS Proprietary Fault Codes (J1708)			
Fault Code	Description			
3018681	Plausibility error clutch open request while inlet valves are closed—internal			
3018781	Plausibility error clutch open request while outlet valves are closed—internal			
3019480	Plausibility error driving direction—internal			
3019621	SmartShift lever data invalid—external (connector X1/8, X1/11, X1/14)			
3019650	Tooth signal interruption speed sensor transmission output (DZ1)—external (connector X2/14)			
3019651	Tooth signal interruption speed sensor transmission input—external (connector X2/11)			
3019652	Tooth signal interruption speed sensor transmission output (D3)—external (connector X2/9)			
3020110	High voltage distance sensor supply—internal			
3020111	Power supply high voltage—external (connector X3/1)			
3020210	Low voltage distance sensor supply—internal			
3020211	Power supply low voltage—external (connector X3/1)			
3021010	Flash checksum error—internal			
3021110	EEPROM calibration values error—internal			
3021610	Clutch displacement offset failure—internal			
3022011	Supply voltage open load—external (connector X3/1)			
3022012	Open load GND connection—external (connector X1/18 and X1/21)			
3022015	Open load pressure sensor signal—internal			
3022018	Plausibility error valve relay V-V1 on—internal			
3022020	Open load GND pump motor—external (connector X3/2)			
3022030	Open load power stage solenoid valve (selection direction R)—internal			
3022031	Open load power stage solenoid valve (selection direction 5/6)—internal			
3022032	Open load power stage solenoid valve—internal			
3022033	Open load power stage solenoid valve (gear direction 1,3,5)—internal			
3022034	Open load power stage solenoid valve (pressure regulation)—internal			
3022041	Open load distance sensor (gear)—internal			
3022042	Open load distance sensor (selection)—internal			
3022044	Open load distance sensor (clutch)—internal			
3022060	Open loop power stage pump motor—internal			
3022115	Short circuit GND pressure sensor signal—internal			
3022130	Short circuit GND power stage solenoid valve (selection direction R)—internal			
3022131	Short circuit GND power stage solenoid valve (selection direction 5/6)—internal			
3022132	Short circuit GND power stage solenoid valve (gear direction R,2,4,6)—internal			
3022133	Short circuit GND power stage solenoid valve (gear direction 1,3,5)—internal			
3022134	Short circuit GND power stage solenoid valve (pressure regulation)—internal			
3022135	Short circuit GND power stage solenoid valve (clutch open 1)—internal			
3022137	Short circuit GND power stage solenoid valve (clutch close 1)—internal			

	AGS Proprietary Fault Codes (J1708)			
Fault Code	Description			
3022141	Short circuit GND distance sensor (gear)—internal			
3022142	Short circuit GND distance sensor (selection)—internal			
3022144	Short circuit GND distance sensor (clutch)—internal			
3022160	Short circuit GND power stage pump motor—internal			
3022215	Short circuit VCC pressure sensor signal—internal			
3022241	Short circuit VCC distance sensor (gear)—internal			
3022242	Short circuit VCC distance sensor (selection)—internal			
3022244	Short circuit VCC distance sensor (clutch)—internal			
3022317	Over temperature power stage pump motor—internal			
3022590	Automatic module: no signal vehicle speed—internal			
3022690	Automatic module: signal group MR (high priority)—internal			
3022790	Automatic module: signal group gear ratio (high priority)—internal			
3022890	Automatic module: learning values engine (high priority)—internal			
3022990	Automatic module: learning values transmission (high priority)—internal			
3024341	Erratic distance sensor (gear)—internal			
3024342	Erratic distance sensor (selection)—internal			
3024344	Erratic distance sensor (clutch)—internal			
3024441	Wrong coil resistance value distance sensor (gear)—internal			
3024442	Incorrect coil resistance value distance sensor (selection)—internal			
3024444	Incorrect coil resistance value distance sensor (clutch)—internal			
3024610	Timeout displacement sensor value—internal			
3026001	CAN bus off—external (connector X1/13 and X1/7)			
3026301	Timeout converted engine data for clutch module (high priority)—internal			
3026501	Timeout internal communication shift module to clutch module (high priority)—internal			
3027401	No J1939 communication—internal / external (connector X1/13 and X1/7)			
3027501	Timeout internal communication shift module to clutch module (high priority)—internal			
3028581	Clutch displacement control failure—internal			
3029180	No calculation of redundant transmission output speed—internal			
3029380	Incorrect transmission type—internal			
3029580	Plausibility error pressure build up—internal			

Table 5, AGS Proprietary Fault Codes (J1708)

For a list of learning procedure errors, see **Table 6**.

Learning Procedure Errors			
Error	Error Description		
56	Offset of clutch position out of range		

Learning Procedure Errors			
Error	Description		
57	Offset of pressure modulation valve out of range		
58	Gear position "neutral" out of range		
61	Low gear position out of range		
62	High gear position out of range		
63	Low select position out of range		
66	High select position out of range		
68	Valve or sensor failure		
69	Vehicle is moving		
70	Low voltage or high voltage		
71	Clutch open/closed		
72	Stalk lever position changed during learning procedure		
73	Type of gear box invalid		
74	Park brake not activated		
76	Engine is running		
77	Engine torque invalid or out of range		
78	Engine was not started in time		
80	Accelerator pedal not idle		
82	Countershaft speed not zero		

Table 6, Learning Procedure Errors

Contents

Subject	Subject Number
General Information	050
Service Operations	
Transmission Removal and Installation	100
Shift Mechanism Removal and Installation	
Input Shaft Removal and Installation	120
Input Shaft Radial Seal Replacement	130
Output Shaft Radial Seal Replacement	140
Front Gear Case Removal and Installation	150
Rear Gear Case Removal and Installation	160
Reverse, First, and Second Gear Disassembly	170
Countershaft Removal and Installation	180
Fifth and Sixth Gear Disassembly	190
Fourth and Third Gear Disassembly	200
Third and Fourth Gear Assembly	210
Sixth and Fifth Gear Assembly	220
Second, First, and Reverse Gear Assembly	230
Synchro Ring Wear Limit Inspection	240
Main Shaft End Play Measurement	250
Specifications	400

General Information

General Information

The Mercedes-Benz transmission (MBT) is offered in two 6-speed models:

- MBT520S-6D, direct drive, 520 lb-ft torque rating
- MBT660S-6O, overdrive, 660 lb-ft torque rating

The gear case holds 9.5 quarts (9.0 liters) of oil. MobilTrans SHC® DC is the approved oil.

Both models are fully synchronized for reduced shifting effort. Equipped with six forward speeds and one reverse speed, both models show a particularly large overall ratio between low and top gear. See **Specifications**, **400** for gear ratios for each model.

To reduce fluid change intervals and to increase bearing life, MBT transmissions are designed with "clean" bearings. These bearings have covers on both sides. They cannot be damaged by the wear particles that accumulate in the fluid. The geometry of the gear teeth has been optimized to provide lownoise operation and extended gear life.

The bell housing has been designed around standard SAE bolt patterns. SAE2 is standard on both MBT660S-6O and MBT520S-6D models.

Other features of the MBT transmissions include:

- Light metal gear cases with integrated bell housings;
- Low installation height (the shift interface is positioned laterally);
- Double synchronization from 1st gear to 4th gear;
- Electronic vehicle speed sensor;
- · Longer oil change intervals;
- Full range of PTO units available.

Each model requires a hydraulic clutch system. No clutches with manual control can be installed for use on MBT transmissions. With the hydraulic system installed, the clutch linkage is self-adjusting.

The hydraulic clutch system consists of the following parts:

- · Hydraulic fluid reservoir;
- · Clutch pedal unit;
- Master cylinder;

- · Slave cylinder;
- Hydraulic lines connecting the various parts of the system.

The MBT transmission removal and installation procedures have been moved to **Subject 100** from their previous location in **Section 26.00**.

The teardown procedures included in this section also apply to the AGS automated transmission, with slight changes which are indicated at appropriate places in the procedures. If it is necessary to tear down the AGS transmission, be sure to remove the AGS assembly before proceeding. See **Section 26.03**, **Subject 200** for procedures.

On all transmissions, disassembly of the transmission main shaft is not recommended except when it is necessary to check for synchronizer wear. Disassembly of the countershaft is not recommended in any case.

It is important to check main shaft end play if either gear case half, the main shaft bearings, or the input shaft is replaced. For detailed procedures, see **Subject 250**.

To prevent premature tool wear, use extreme pressure lubricant such as Kent-Moore J 23444-A or equivalent on tool threads and at all friction and contact points.

Removal

- Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the rear tires.
- 2. Drain the transmission fluid. See **Fig. 1** for the location of the drain plug.

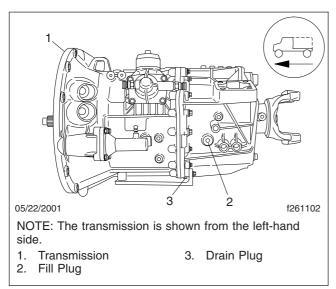


Fig. 1, Transmission Drain and Fill Plugs

- 3. Disconnect the driveshaft from the transmission.
 - 3.1 Support the midship bearing.
 - 3.2 Remove the bolts from the U-joint end caps and slide the front of the driveshaft out of the transmission output yoke. See Fig. 2.
 - 3.3 Remove the midship bearing bracket. See Fig. 3.
 - 3.4 Support the disconnected driveshaft and chain it out of the way. See **Fig. 4**.
- 4. Remove the shift lever from the transmission.
 - 4.1 Before removing the shift lever, place the transmission in high gear.
 - 4.2 Remove the four screws from the retaining ring around the shift lever boot. See Fig. 5. Remove the ring and the boot.
 - 4.3 Remove the head of the shift lever from the transmission. See **Fig. 6**. For ease of

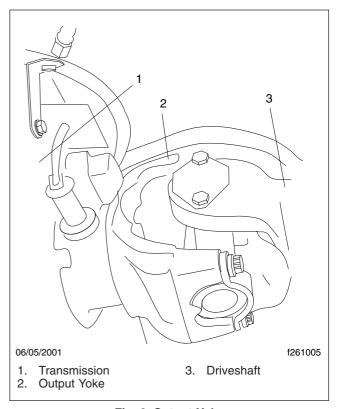


Fig. 2, Output Yoke

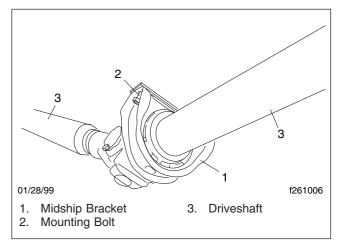


Fig. 3, Midship Bearing Bracket

installation, mark the head of the shift lever and the attachment point on the transmission with a paint pen.

5. Remove the fuel lines and the fuel line standoff bracket from the transmission. See Fig. 7.

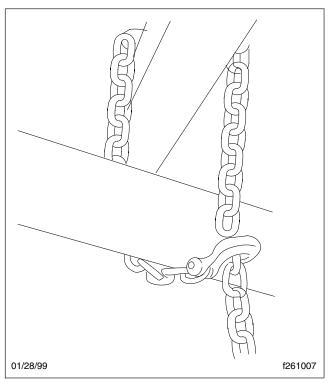


Fig. 4, Supporting the Driveshaft

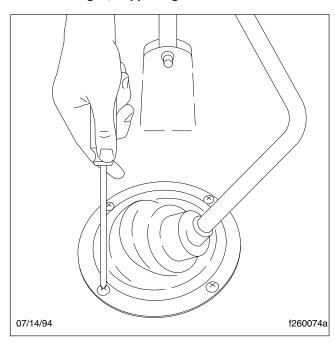
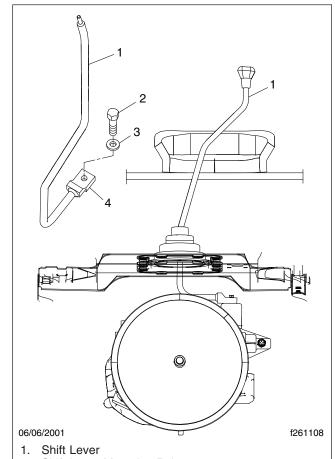


Fig. 5, Shift Lever and Boot



- 2. Shift Lever Mounting Bolt
- 3. Thick Washer
- 4. Head of Shift Lever

Fig. 6, Shift Lever Connection

 Disconnect the electrical connectors for the reverse gear switch and the optional starter lock switch (if installed). Mark with a paint pen for ease of installation.



Do not press down on the clutch pedal after removing the slave cylinder. Hydraulic brake fluid may squirt out, causing personal injury and damage to the vehicle.

 Remove the bolts that attach the clutch slave cylinder to the mounting flange on the gear case. Move the slave cylinder out of the way. See Fig. 8.

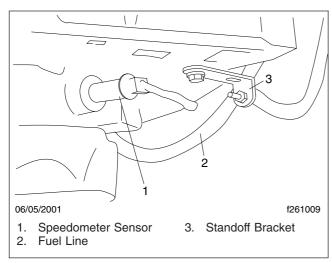


Fig. 7, Fuel Line Standoff Bracket and Speedometer Sensor

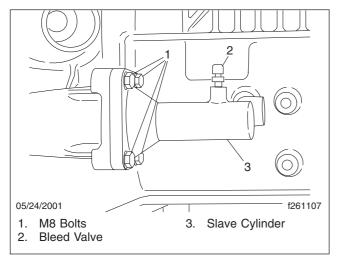


Fig. 8, Hydraulic Clutch Slave Cylinder

- 8. Bend back the nut retainers and remove the power take-off unit (PTO), if installed. See Fig. 9.
- 9. If the vehicle is equipped with optional dual fuel tanks, remove the fuel cross-over line and its support between the tanks.
- Disconnect the electrical cable from the speedometer sensor and mark it with a paint pen for ease of installation. See Fig. 7.
- 11. Remove the battery cable bracket(s) around the transmission and move the battery cables out of the way. See Fig. 10.

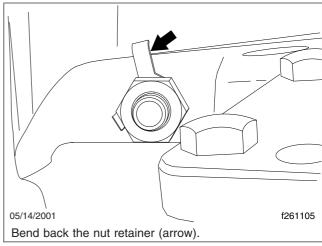


Fig. 9, Power Take-Off Unit (PTO) Nut Retainers

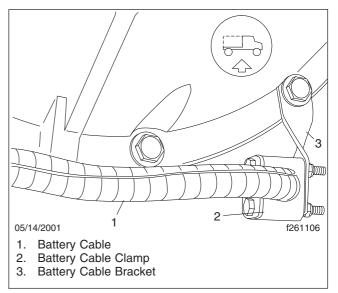


Fig. 10, Battery Cable Routing

- Remove the exhaust clamp at the exhaust elbow.
 For ease of transmission removal and installation, move the exhaust pipe to the side and out of the way.
- 13. Support the transmission with a jack. See Fig. 11.
 - 13.1 Position a transmission jack under the transmission and raise its support plates against the base of the transmission.
 - 13.2 Adjust the support plates to cradle the transmission.

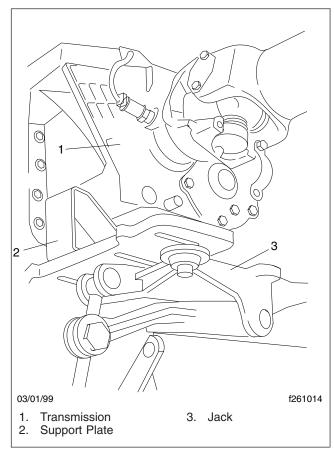


Fig. 11, Supporting the Transmission

- 13.3 Using a chain, secure the transmission to the jack.
- Remove the 16-mm transmission mounting capscrews that attach the timing case to the bell housing. See Fig. 12.
 - 14.1 Remove the eleven transmission mounting capscrews.
 - 14.2 After removing the transmission, insert the capscrews into the holes in the timing case, rather than in the bell housing.



Do not allow the rear of the transmission to drop, and do not allow the transmission to hang unsupported. Keep the flange of the bell housing parallel (all the way around) to the flange of the timing case, until the input shaft is clear of the

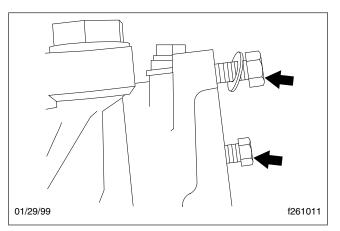


Fig. 12, Capscrews Left in the Timing Case

flywheel. Taking these precautions will prevent damage to the input shaft, flywheel, and clutch.

 After making sure that the transmission is firmly secured and well supported, remove the transmission from the vehicle. See Fig. 13.

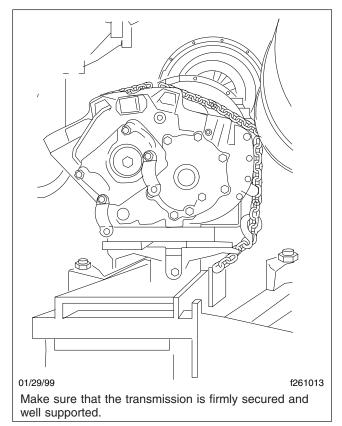


Fig. 13, Transmission Ready To Remove

- 15.1 Pull the transmission and jack straight back until the transmission input shaft is clear of the clutch.
- 15.2 Turn the left-hand front wheel to allow room for the transmission to pass. If necessary, lower the jack supporting the transmission. It might also be necessary to jack up the truck to get enough clearance to allow the transmission to pass.

IMPORTANT: Watch closely the clearance between the bell housing and the leaf spring.

15.3 Pull the transmission out through the space behind the front wheel.

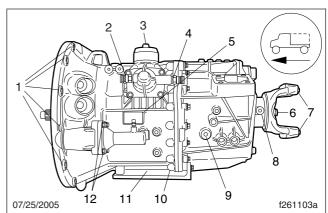
Installation

IMPORTANT: Before installing the transmission, make sure that the rear tires are chocked and that the transmission is securely chained to the support plates on the transmission jack.

- 1. Install the transmission. See Fig. 14.
 - 1.1 Align the jack and the transmission behind the engine.
 - 1.2 Raise the transmission and adjust the angle of the jack until the bell housing and the timing case flange are parallel.
 - 1.3 Push the transmission and jack straight forward.

NOTE: While installing the transmission mounting capscrews, also install the battery cable bracket(s), as removed.

- 1.4 Install the eleven M10 transmission mounting capscrews. Use a crossover pattern. Do a final tightening of the capscrews to 33 lbf·ft (45 N·m).
- 1.5 Remove the chain around the transmission and the jack; then remove the jack.
- 2. Install the exhaust clamp at the exhaust elbow, as removed.
- If the vehicle is equipped with the optional dual fuel tanks, install the fuel cross-over line and its support between the tanks. Tighten the clamps 40 lbf·ft (54 N·m) and the mounting bolts 95 lbf·ft (129 N·m).



NOTE: The transmission is shown from the left-hand side.

- 1. Transmission Mounting Capscrews
- 2. Reverse Gear Switch
- 3. Shift Lever Mounting Bolt
- 4. Starter Lock Switch
- 5. Nameplate
- 6. Output Yoke Pressure Plate Mounting Capscrew
- 7. U-Joint End Cap Bolts
- 8. Speedometer Sensor Lock
- 9. Transmission Fluid Fill Plug
- 10. Transmission Fluid Drain Plug
- 11. PTO Mounting Capscrews
- 12. Clutch Slave Cylinder Mounting Bolts

Fig. 14, Transmission Fasteners

- 4. If removed, coat the mating surface of the PTO cover with Loctite® 509 or equivalent sealing compound. Install the PTO cover on the transmission. Tighten the M10 hardened mounting capscrews 43 lbf·ft (58 N·m). Lock the nut retainers in place.
- 5. Connect the driveshaft.
 - 5.1 Slide the front of the driveshaft into the transmission output yoke.
 - 5.2 Install the U-joint end caps on the output yoke. Tighten the bolt heads 50 lbf-ft (68 N·m) for 3/8-inch end cap bolts and 110 lbf-ft (149 N·m) for 1/2-inch end cap bolts.
 - 5.3 Install the midship bearing bracket, as removed. Tighten the nuts 95 lbf·ft (129 N·m).
- 6. Install the fuel line standoff bracket and connect the fuel lines to the bracket.

- 7. Connect the electrical connectors. Connect the electrical cable to the speedometer sensor. Connect the electrical connector(s) on the shift lever.
- 8. Install the shift lever.
 - 8.1 Fit the shift lever over the cone of the transmission tower.
 - 8.2 Coat the hardened M10 x 20 shift lever mounting bolt with Loctite 242 or equivalent thread-locking compound.
 - 8.3 Insert the M10 bolt and a thick washer into the hole in the shift lever. See **Fig. 6**. Use the markings made during removal to install the shift lever in the correct orientation, so as to avoid cab floor interference.

IMPORTANT: Don't forget to install the washer. Without the washer, the shift lever may loosen. The driver could lose control of the vehicle.

- 8.4 Tighten the M10 bolt 50 lbf-ft (68 N·m).
- 8.5 Work the shift lever around to make sure it shifts comfortably in all gears.
- 8.6 Install the rubber boot and the metal retaining ring. Install the four screws and tighten against the cab floor 28 lbf·ft (38 N·m). See Fig. 5.
- Fasten the clutch slave cylinder to the mounting flange on the gear case and tighten the four M8 slave cylinder mounting bolts 15 lbf-ft (20 N·m).
- If necessary, bleed the hydraulic clutch system. See Section 25.02, Subject 140 for detailed instructions.
- 11. Clean the transmission drain plug and install it in the gear case, along with a new aluminum gasket. Tighten the drain plug 42 lbf·ft (57 N·m).
- 12. Add Mobiltrans SHC® DC until the transmission fluid is level with the lower edge of the fill opening. See Fig. 1 for the location of the fill plug and Fig. 15 for checking the correct level. About 9.5 quarts (9.0 liters) is needed.
- 13. Clean the transmission fill plug and install it in the gear case, along with a new aluminum gasket. Tighten the fill plug 42 lbf·ft (57 N·m).
- 14. Remove the chocks from the rear tires.

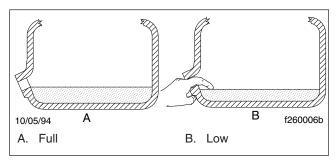


Fig. 15, Transmission Fluid Level Checking

Shift Mechanism Removal and Installation

NOTE: These procedures are for the manual transmission with shift lever only. For the automated AGS transmission, see **Section 26.03**, **Subject 200**.

Removal

- Remove the transmission. For detailed procedures, see Subject 100.
- 2. Secure the transmission on a wooden pallet, or other device to keep it from moving.
- 3. Make sure the transmission is in neutral.
- 4. Remove the four capscrews that attach the shift rod housing to the flange on the front gear case. See Fig. 1.

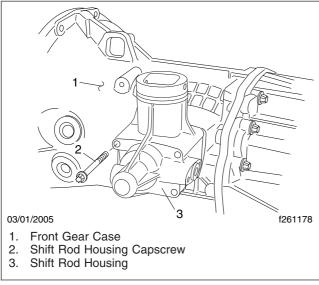


Fig. 1, Shift Mechanism

- 5. Remove the shift rod from the front gear case.
 - 5.1 From the right-hand side of the transmission, remove the setscrew that holds the end of the shift rod. Discard the old setscrew.
 - 5.2 Remove and discard the shift rod cover from the right-hand side of the gear case.
 - 5.3 Pull the shift rod all the way out of the gear case.

Installation

NOTE: See the installation procedure in **Section 26.03**, **Subject 200** for more information on the proper alignment of the shift finger in the shift rod.

- Make sure that the indent in the shift rod end (shown by the arrow in Fig. 2) is facing aft for proper engagement with the setscrew.
- 2. Install the shift rod in the front gear case.
 - 2.1 Insert the shift rod into the front gear case.
 - 2.2 Turn the shift rod until the dimple is at the 9 o'clock position.
- Install the shift rod housing on the front gear case.
 - 3.1 Push the housing in until the indent in the rod end is showing in the setscrew hole.
 - 3.2 Coat the threads of a new setscrew with Loctite® 242 or equivalent thread-locking compound. Insert the new setscrew and tighten it 30 lbf·ft (40 N·m). See Fig. 3.
 - 3.3 Install a new shift rod cover in the shift cover housing.
 - 3.4 Position the shift rod housing over the flange in the front gear case. Coat the mating surfaces with a bead of Loctite 509 or equivalent sealing compound.
 - 3.5 Install the four capscrews that attach the shift rod housing to the front gear case. Coat the threads of the two lower capscrews with Loctite 242 or equivalent thread-locking compound. Tighten all four capscrews 18 lbf·ft (25 N·m).
- 4. Install the transmission. For detailed procedures, see **Subject 100**.

Shift Mechanism Removal and Installation

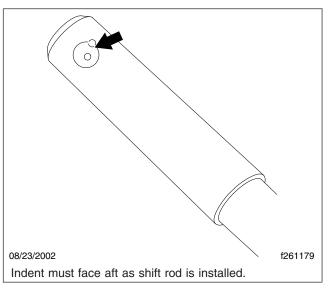


Fig. 2, Shift Rod End

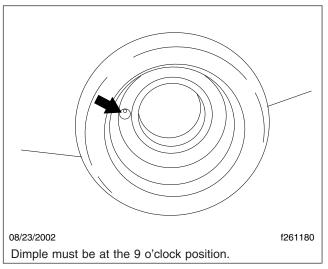


Fig. 3, Shift Mechanism Setscrew

Input Shaft Removal and Installation

Special Tools

A special tool is required for this procedure. See **Table 1**.

Special Tool for Input Shaft Replacement					
Tool	Description	Manufacturer	Part Number		
f580393	Snap Ring Removal Tool	Kent-Moore	J-46730		

Table 1, Special Tool for Input Shaft Replacement

Removal

- With the transmission removed from the vehicle and secured to keep it from moving, remove the shift mechanism. For instructions, see Subject 110.
- 2. Remove the front gear case. For instructions, see **Subject 150**.
- 3. Remove the input shaft radial seal. For instructions, see **Subject 130**.
- 4. Remove and discard the upper snap ring underneath the radial seal. See Fig. 1.
- 5. Press the input shaft out of the front gear case.
- Using the snap ring removal tool, remove and discard the half-round snap ring under the deepgroove ball bearing. See Table 1 for tool information and Fig. 2 for tool application.
- 7. Press the deep-groove ball bearing out of the front gear case.

Installation

1. Heat the front gear case in the area of the bearing seat to 176°F (80°C).

IMPORTANT: Press only on the outer race of the deep-groove ball bearing.

 When the gear case is properly heated, install the deep-groove ball bearing into its seat. Install a new half-round snap ring.

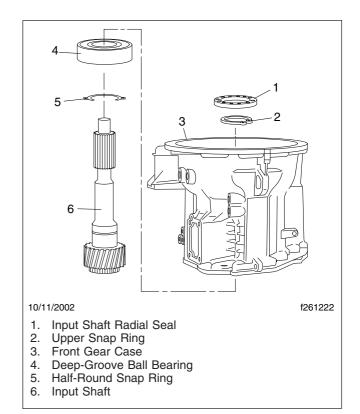


Fig. 1, Input Shaft Assembly

- 3. Using a feeler gauge, measure the gap between the deep-groove ball bearing and the half-round snap ring. This measurement should not be more than 0.0003 inch (0.007 mm).
- 4. Heat the deep-groove ball bearing 176°F (80°C).

Input Shaft Removal and Installation

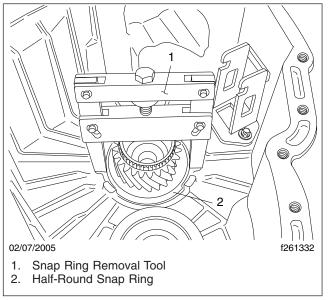


Fig. 2, Half-Round Snap Ring Removal

- When the bearing is properly heated, install the input shaft into the seat in the front gear case. Install a new upper snap ring.
- 6. Using a feeler gauge, measure the gap between the deep-groove ball bearing and the upper snap ring. This measurement should not be more than 0.0003 inch (0.007 mm).
- 7. Check main shaft end play. For procedures, see **Subject 250**.
- 8. Install the input shaft radial seal. For instructions, see **Subject 130**.
- Install the front gear case. For instructions, see Subject 150.
- Install the shift mechanism. For instructions, see Subject 110.

Input Shaft Radial Seal Replacement

Special Tools

A special tool is required for this procedure. See **Table 1**.

Special Tool for Input Shaft Radial Seal Replacement					
Tool Description Manufacturer Part Number					
f580401	Input Shaft Seal Installer	Kent-Moore	J-47901		

Table 1, Special Tool for Input Shaft Radial Seal Replacement

Replacement

- Remove the transmission. For detailed procedures, see Subject 100.
- 2. Secure the transmission on a wooden pallet, or other device to keep it from moving.
- 3. Remove the release fork and release bearing.

NOTE: On AGS transmissions, remove the clutch actuator. For procedures, see **Section 26.03**, **Subject 120**.

- Remove the guide tube from the transmission case. Discard the mounting bolts. See Fig. 1.
- Remove the radial seal from the input shaft. Discard the old radial seal.

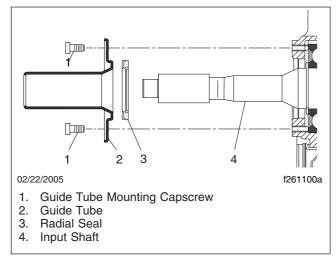


Fig. 1, Input Shaft Radial Seal Replacement



To prevent damage, make sure that the new radial seal is not installed on the race of the old seal.

 Using the input shaft seal installer, install a new radial seal on the input shaft. See Table 1 for tool information and Fig. 2 for tool application.

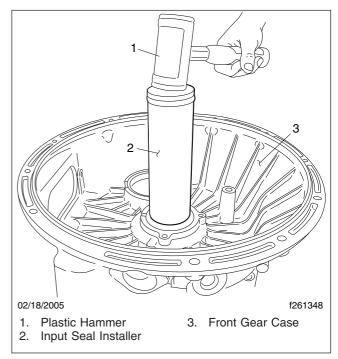


Fig. 2, Installing the Input Shaft Radial Seal

Input Shaft Radial Seal Replacement

- 7. Install the guide tube on the transmission case. Use new M8 x 18 low-profile guide tube mounting capscrews. Tighten the capscrews 17 lbf·ft (23 N·m).
- 8. Install the release fork and release bearing. Tighten the release fork mounting capscrews 26 lbf·ft (36 N·m).
- 9. Install the transmission. For detailed procedures, see **Subject 100**.

Output Shaft Radial Seal Replacement

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools for Output Shaft Radial Seal Installation				
Tool	Description	Manufacturer	Part Number	
f580398	Output Shaft Seal Installer	Kent-Moore	J-47863	
f580400	Universal Handle	Kent-Moore	J-8901	

Table 1, Special Tools for Output Shaft Radial Seal Installation

Replacement

- Secure the output yoke so that it cannot turn the output shaft.
- 2. Remove the pressure plate mounting capscrew. Remove the pressure plate. See **Fig. 1**.

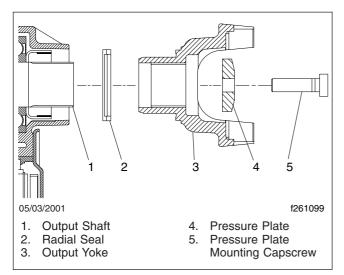


Fig. 1, Output Yoke Assembly

3. Remove the output yoke. Use a suitable extractor tool.

- 4. Remove the radial seal from the output shaft. Discard the old radial seal.
- Assemble the output shaft seal installer onto the threaded end of the universal handle. See Table 1.



To prevent damage, make sure that the new radial seal is not installed on the race of the old seal.

- 6. Using the output shaft seal installer assembly, install a new radial seal on the output shaft. See Fig. 2.
- 7. If the output yoke cannot be pressed on cold, preheat the output yoke to 176°F (80°C) and try again.
- 8. Position the pressure plate on the output shaft. Secure it to the shaft using the pressure plate mounting capscrew. Tighten the M16 capscrew 190 lbf-ft (258 N·m).

Output Shaft Radial Seal Replacement

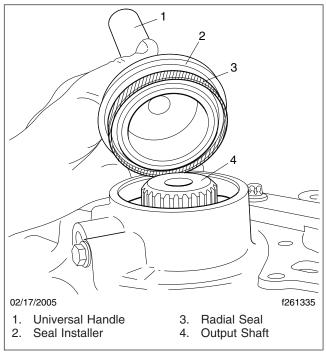


Fig. 2, Output Shaft Radial Seal Ready to Install

Special Tools

Special tools are required for these procedures. See **Table 1**.

To prevent premature tool wear, use extreme pressure lubricant such as Kent-Moore J 23444-A or equivalent on tool threads and at all friction and contact points.

Special Tools for Front Gear Case Removal and Installation				
Tool	Description	Manufacturer	Part Number	
Rear Case Puller/Installer/Stand		Kent-Moore	J-46739	
f580390	Front Gear Case Bridge	Kent-Moore	J-46727	
f580389	Synchro Retainer Clips	Kent-Moore	J-46726	
f580399	Countershaft Seal Cover Installer	Kent-Moore	J-47901	
(f580400	Universal Handle	Kent-Moore	J-8901	
(∂ (∂ () () () () () () () () () () () () ()	Countershaft Retainer	Kent-Moore	J-46733	

Table 1, Special Tools for Front Gear Case Removal and Installation

Removal

 With the transmission removed from the vehicle and secured to keep it from moving, remove the shift mechanism. For instructions, see Subject 110.

NOTE: Take care that the tone wheel does not gouge the walls of the rear case where it opens to admit the output shaft.

- 2. Remove the output yoke and output shaft radial seal from the rear gear case.
- 3. Remove the rear countershaft cover from the output end of the rear gear case.
- 4. Remove the speed sensor from the output shaft. Remove the plug for the oil temperature sensor on the back of the rear gear case.

NOTE: On AGS transmissions, remove two speed sensors on the output shaft and one on the lower left-hand side of the rear gear case.

- 5. Remove the shift rail detent bolts.
- 6. Remove the shift rail cover from the output end of the rear gear case. See Fig. 1.

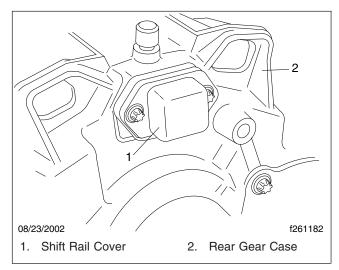


Fig. 1, Shift Rail Cover

 Attach the rear case puller/installer/stand to the output end of the rear gear case. See **Table 1**. Coat the all-thread rod with J 23444-A extreme pressure lubricant. NOTE: J 23444-A extreme pressure lubricant can be ordered from SPX Kent-Moore at 1-800-345-2233.

8. Stand the transmission on the puller/installer/ stand. See Fig. 2.

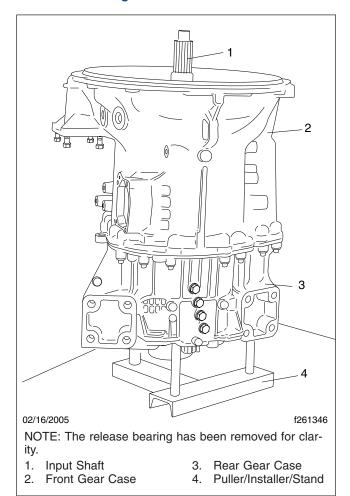
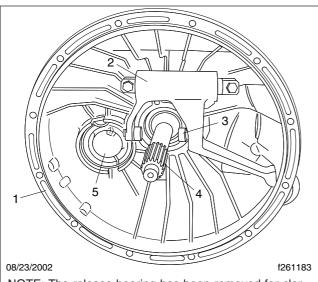


Fig. 2, Transmission on the Puller/Installer/Stand

- 9. Remove the guide tube, the input shaft radial seal, and the inner snap ring. For instructions, including removal of the clutch release bearing and release fork, see **Subject 130**.
- 10. Remove the snap ring on the front countershaft seal cover. See **Fig. 3**.
- Remove and discard the front countershaft seal cover. The seal cover may be difficult to remove. Use a pry tool and/or screwdriver as shown in Fig. 4.



NOTE: The release bearing has been removed for clarity.

- 1. Front Gear Case
- 2. Release Fork
- 3. Pressure Point
- 4. Input Shaft
- 5. Front Countershaft Seal Cover

Fig. 3, Front End of Transmission

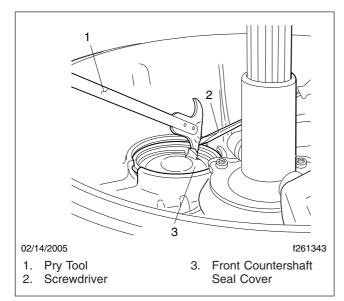
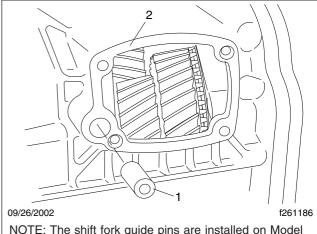


Fig. 4, Prying Out the Front Countershaft Seal Cover

12. Remove the two snap rings on the countershaft ball bearing. Discard the snap rings.

13. On model 660 only, pull out the two shift fork guide pins, one located on the left-hand side in the flanged mating surface of the shift rod housing and the other on the right-hand side of the front gear case next to the shift cover (this pin has a T60 Torx® head). See Fig. 5.



NOTE: The shift fork guide pins are installed on Model 660 only.

- 1. Shift Fork Guide Pin (left-hand side)
- 2. Flange

Fig. 5, Pulling the Left-Hand Shift Fork Guide Pin

- 14. Remove the gear case capscrews that attach the front gear case to the rear gear case. See Fig. 6.
- 15. After removing the capscrews, pry up on the front gear case to break the seal. Do not remove the front gear case at this time.
- 16. Using the front gear case bridge, remove the front gear case from the rear gear case and twin transmission shafts. See **Table 1** for more information about the special tool.
 - 16.1 Install the front gear case bridge so the hole is centered over the countershaft. Fasten it to the lip of the gear case with two gear case capscrews. See Fig. 7.
 - 16.2 Carefully press the front gear case off the countershaft and rear gear case. See Fig. 8.
- 17. Clean any remnants of sealant from the mating surfaces of the two gear case halves.
- 18. On model 660 only, remove the 5th/6th gear fork on the 5th/6th gear synchro slide and shift rail.

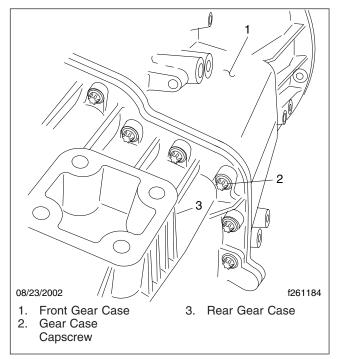


Fig. 6, Gear Case Capscrews

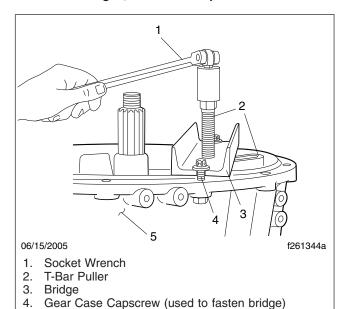


Fig. 7, Front Gear Case Bridge

19. After the case comes off, install the synchro retainer clips on the 5th/6th gear synchros. See

- Fig. 9 for the installation and Table 1 for more information about the special tool.
- 20. Remove the countershaft ball bearing from the front gear case.
- 21. Remove the pilot bearing from the main shaft.

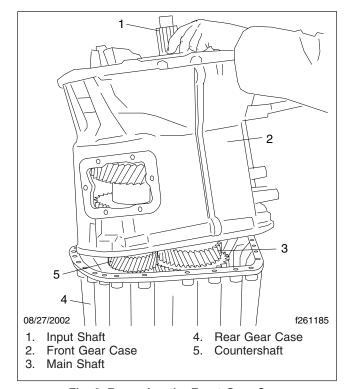


Fig. 8, Removing the Front Gear Case

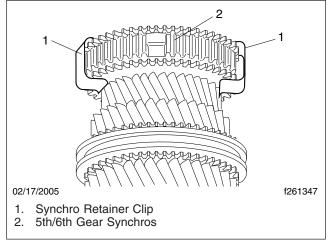


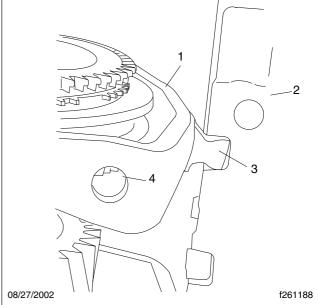
Fig. 9, Installing the Synchro Retainer Clips

5. Front Gear Case

Installation

NOTE: If either gear case half, the main shaft bearings, or the input shaft was replaced, check the main shaft end play. For detailed procedures, see **Subject 250**.

- Lubricate the pilot bearing with approved transmission oil. Install the pilot bearing on the main shaft.
- 2. Remove the synchro retainer clips from the 5th/6th gear synchros.
- On model 660 only, install the 5th/6th gear fork on the 5th/6th gear synchro slide and shift rail. Make sure the shoes on the fork are properly positioned. The finger of the 5th/6th gear fork must engage the available notch in the shift rail. See Fig. 10.
- 4. Apply a bead of Loctite® 509 or equivalent sealing compound along the entire mating surface of the rear gear case, going fully around each hole and cavity.
- Lift the front gear case onto the rear gear case. Carefully align the case over the shift rods. Install the gear case capscrews and tighten them 22 lbf·ft (30 N·m).
- On model 660 only, check the 5th/6th gear fork through the opening for the shift rod housing to make sure the correct engagement of the finger has been maintained. See Fig. 10. Install the shift rail detent bolts finger-tight.
- 7. Install the shift fork guide pins, if removed (model 660 only). See **Fig. 11**.
 - 7.1 On the left-hand side, the pin slides in and is held in place by the shift mechanism when installed.
 - 7.2 On the right-hand side, coat the threads of the T60 Torx fastener with Loctite 242 or equivalent thread-locking compound, and tighten the fastener 88 lbf·ft (120 N·m).
- 8. Using a heat gun, warm the countershaft bearing seat to 176°F (80°C). Install the countershaft ball bearing on the countershaft by pressing on the inner race. Install two new snap rings.
- Assemble the countershaft seal cover installer onto the threaded end of the universal handle. See Table 1.



The finger of the 5th/6th gear fork must continue to engage the available notch in the shift rail.

- 1. 5th/6th Gear Fork
- 2. Shift Rail
- 3. Finger
- 4. Hole for Insertion of Shift Fork Guide Pin (model 660 only)

Fig. 10, Correct Finger Engagement

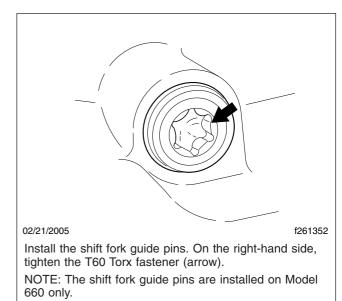


Fig. 11, Tighten the T60 Fastener

 Using the countershaft seal cover installer assembly, carefully press the front countershaft seal cover onto the countershaft. See Fig. 12.

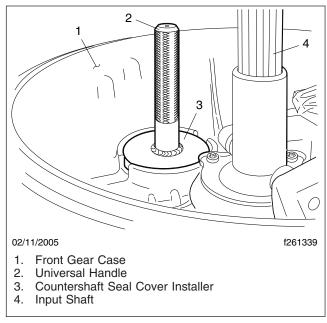


Fig. 12, Pressing the Front Countershaft Seal Cover

- 11. Install the snap ring on the front countershaft seal cover. Remove the countershaft retainer from the rear gear case. See **Table 1** for more information about the countershaft retainer.
- Install the input shaft radial seal. For instructions, including installation of the clutch release bearing and release fork, see Subject 130.
- 13. Turn the transmission so the output end is exposed. Remove the puller/installer/stand.
- 14. Install the speed sensor on the output shaft, as removed. Install the plug for the oil temperature sensor on the back of the rear gear case.

NOTE: On AGS transmissions, install two speed sensors on the output shaft and one on the lower left-hand side of the rear gear case.

- 15. Coat the mating surface of the shift rail cover with Loctite 509 or equivalent sealing compound. Install the shift rail cover on the output end of the rear gear case. Tighten the shift rail cover capscrews 29 lbf·ft (39 N·m).
- 16. Tighten the shift rail detent bolts 22 lbf⋅ft (30 N⋅m).

- Coat the mating surface of the rear countershaft cover with Loctite 509 or equivalent sealing compound. Install the rear countershaft cover.
 Tighten the rear countershaft cover capscrews 18 lbf·ft (25 N·m).
- Install the output shaft radial seal. For procedures, see Subject 140. Install the output yoke on the rear gear case.
- Install the shift mechanism. For instructions, see Subject 110.

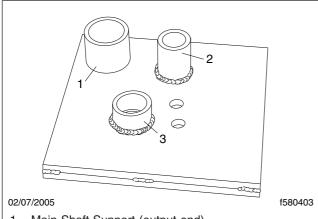
Special Tools

Special tools are required for these procedures. See **Table 1**.

To prevent premature tool wear, use extreme pressure lubricant such as Kent-Moore J 23444-A or equivalent on tool threads and at all friction and contact points.

Removal

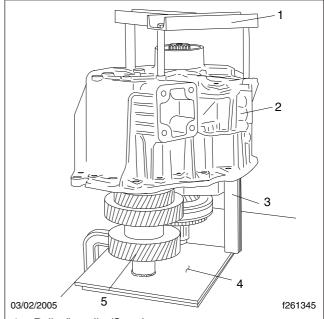
- 1. Secure the transmission on a wooden pallet, or other device to keep it from moving.
- Remove the front gear case. For instructions, see Subject 150.
- Install the main shaft/countershaft stand on the exposed gear shafts. For more information about the main shaft/countershaft stand, see Table 1 and Fig. 1.
- 4. Turn the transmission over and set it down with the rear case up. See **Table 1** for more information about the puller/installer/stand.



- 1. Main Shaft Support (output end)
- 2. Main Shaft Support (input end)
- 3. Countershaft Support

Fig. 1, Main Shaft/Countershaft Stand

- 5. Stand the transmission on the main shaft/ countershaft stand and secure the stand to the table with a clamp. See Fig. 2.
- 6. Using the reverse idler shaft puller, remove the reverse idler shaft. For more information about the reverse idler shaft puller, see **Table 1**.



- 1. Puller/Installer/Stand
- 2. Rear Gear Case
- 3. Shift Rails
- 4. Main Shaft/Countershaft Stand
- 5. Main Shaft

Fig. 2, Transmission with the Rear Case Up

6.1 Coat the forcing screw running through the puller body with J 23444-A extreme pressure lubricant.

NOTE: J 23444-A extreme pressure lubricant can be ordered from SPX Kent-Moore at 1-800-345-2233.

- 6.2 Insert the small-diameter threaded end of the forcing screw into the reverse idler shaft. Tighten the locknut on the forcing screw against the reverse idler shaft. Figure 3 shows the reverse idler shaft puller installed.
- 6.3 Attach a suitable wrench, socket or boxend, to the nut at the top end of the forcing screw, and turn the large nut clockwise until the reverse idler shaft is pulled up.

 Figure 4 shows the reverse idler shaft ready for removal.

Special Tools for Rear Gear Case Removal and Installation						
Tool	Description Manufacturer		Part Number			
f580395	Main Shaft/Countershaft Stand Kent-Moore		J-46732			
f580397	Rear Case Puller/Installer/Stand Kent-		J-46739			
f580394	Reverse Idler Shaft Puller	Kent-Moore	J-46731			
f580391	Countershaft Guide		J-46728			
Countershaft Retainer		Kent-Moore	J-46733			

Table 1, Special Tools for Rear Gear Case Removal and Installation

- 6.4 Remove the reverse idler shaft and puller from the rear gear case. Separate the reverse idler shaft from the puller.
- 7. Make sure the speed sensor has been removed.

IMPORTANT: On AGS transmissions, there are three speed sensors on the rear gear case: the input shaft speed sensor on the lower left-hand side, and the two output shaft speed sensors on the rear output flange.

- 8. Pull the rear gear case from the twin gear shafts. See Fig. 5.
- 8.1 Install the all-thread rod and two nuts through the puller/installer/stand and into the output shaft. Lubricate the rod threads with high-pressure grease. Tighten one nut against the other to create a jam nut.
- 8.2 Using a socket wrench, hold the jam nut at the head of the all-thread rod.
- 8.3 Install two washers between the puller/ installer/stand and the working nut. Using an open-end wrench, turn the working nut counterclockwise.

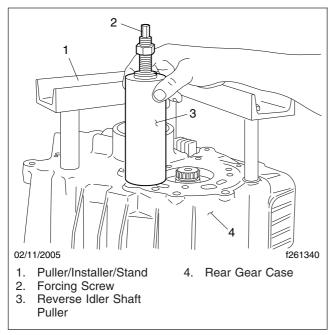


Fig. 3, Reverse Idler Shaft Puller Installed

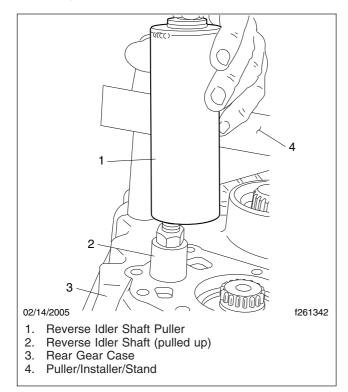
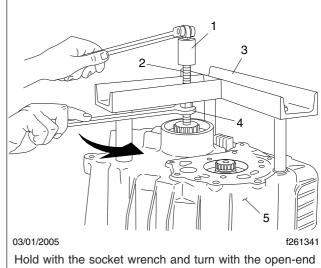


Fig. 4, Reverse Idler Shaft (ready for removal)



wrench in the direction of the arrow.

- 1. Socket Wrench on Jam Nut
- 2. All-Thread Rod
- 3. Puller/Installer/Stand
- 4. Open-End Wrench on Working Nut
- 5. Rear Gear Case

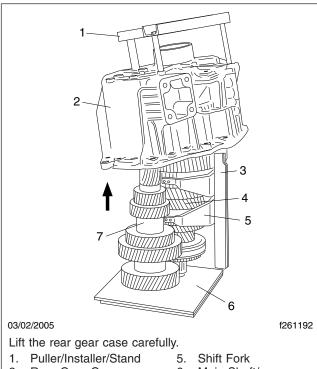
Fig. 5, Raising the Rear Gear Case

- 8.4 Keep turning the working nut until the rear case releases from the main shaft.
- Remove the all-thread rod from the output 8.5 shaft.
- 9. Carefully lift the rear gear case off the gear shafts. See Fig. 6. Leave the puller/installer/ stand installed.
- 10. The reverse idler gear may hang up on the gear below it. Carefully remove the reverse idler gear and needle bearing. Inspect them for damage.
- 11. Separate the puller/installer/stand from the rear gear case.

Installation

NOTE: During installation, the transmission should be standing on the main shaft/ countershaft stand with the output end of the rear gear case exposed.

1. Place the reverse idler gear and needle bearing in the rear gear case.



- Rear Gear Case 2.
- Shift Rail 3
- Main Shaft
- 6. Main Shaft/
 - Countershaft Stand
- Countershaft

Fig. 6, Removing the Rear Gear Case

- Install the shift rails and forward shift forks on the gear shafts.
- Install the countershaft guide. For more information about the countershaft guide, see Table 1. Figure 7 shows the guide installed on the countershaft.
- 4. Install the rear gear case, with the puller/installer/ stand on the exposed gear shafts. See Fig. 8.
- Lower the rear gear case onto the gear shafts.
 - Install the all-thread rod into the output 5.1 shaft.

IMPORTANT: As the rear gear case is being lowered, carefully inspect the reverse idler gear and make sure that it meshes.

- 5.2 Hold a socket wrench on the bolt head.
- 5.3 Using an open-end wrench, turn the nut.
- 5.4 Continue the process of turning the nut until the rear case bottoms out.

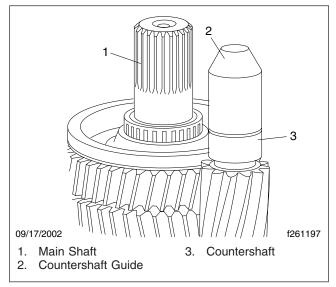
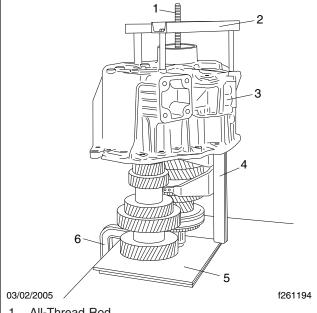


Fig. 7, Countershaft Guide



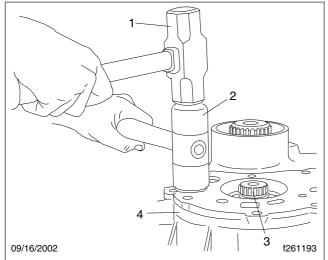
- 1. All-Thread Rod
- Puller/Installer/Stand
- 3. Rear Gear Case
- Shift Rails
- Main Shaft/Countershaft Stand 5.
- Clamp

Fig. 8, Installing the Rear Gear Case

NOTE: At the start, only a small bit of the machined surface of the idler shaft will be visible.

When finished, the idler shaft must be flush with the surface of the gear case.

6. Install the reverse idler shaft in the rear gear case. Use two hammers as shown in **Fig. 9**, with the metal-faced hammer doing the striking, and the dead-blow hammer transmitting the force of the blow to the reverse idler shaft.



Use two hammers: a metal-faced one to strike with, and a dead-blow hammer to transmit the force of the blow.

- Metal-Faced
 Hammer
- 3. Countershaft
- Hammer 4. Rear Gear Case
- Dead-Blow Hammer

Fig. 9, Installing the Reverse Idler Shaft

- Install the countershaft retainer on the rear gear case. Figure 10 shows the countershaft retainer installed. See Table 1 for more information about the countershaft retainer.
- 8. Remove the all-thread rod from the puller/installer/stand. Turn the transmission over and place it rear case down on the puller/installer/stand. Remove the main shaft/countershaft stand.
- 9. Align the detents in each shift rail with the bolt holes in the rear case. See Fig. 11.

NOTE: Check the main shaft end play. For detailed procedures, see **Subject 250**.

 Turn the transmission over and set it down with the rear case down. Remove the main shaft/ countershaft stand.

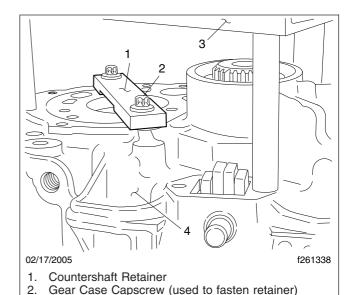


Fig. 10, Countershaft Retainer Installed

Puller/Installer/Stand
 Rear Gear Case

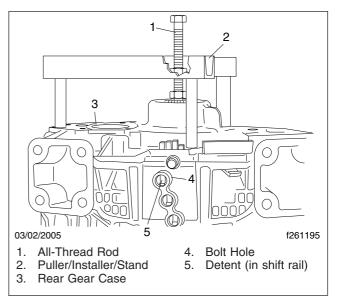


Fig. 11, Shift Rail Detents

11. Install the front gear case. For instructions, see **Subject 150**.

Reverse, First, and Second Gear Disassembly

Special Tools

A special tool is required for these procedures. See **Table 1**.

Special Tool for Reverse, First, and Second Gear Disassembly							
Tool	Description	Manufacturer	Part Number				
(580395)	Main Shaft/Countershaft Stand	Kent-Moore	J-46732				

Table 1, Special Tool for Reverse, First, and Second Gear Disassembly

Reverse Gear

- Secure the transmission on a wooden pallet, or other device to keep it from moving.
- 2. Remove the shift mechanism. For instructions, see **Subject 110**.
- 3. Remove the front gear case. For instructions, see **Subject 150**.
- 4. Remove the rear gear case. For instructions, see **Subject 160**.
- 5. Make sure the twin gear shafts are supported on the main shaft/countershaft stand. See **Table 1**.
- 6. Remove the shift bars and shift forks from the transmission. See **Fig. 1**.
 - 6.1 Lift the 5th/6th gear fork off the shift bars.
 - 6.2 Pull the remaining shift forks and shift bars away from the main shaft as a group.
 - 6.3 Tie the shift bars and forks together.
- 7. Inspect the synchro rings for compliance with the wear limits given in **Subject 240**.
- 8. Remove the reverse gear wheel and needle bearing from the main shaft.

First Gear

1. Using suitable snap ring pliers, remove the 1st gear snap ring from the main shaft. Measure the

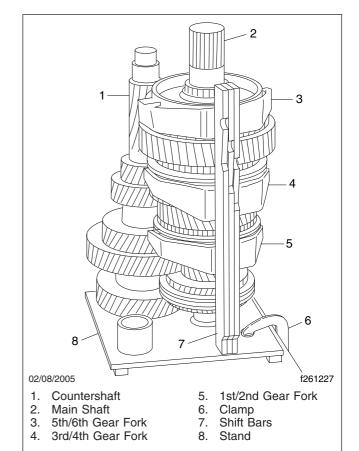


Fig. 1, Shift Bars and Forks

snap ring thickness and record it. Discard the snap ring after recording its thickness.

Reverse, First, and Second Gear Disassembly

- 2. Remove the inner gear wheel.
- 3. Remove the 1st gear wheel and the needle bearing. See Fig. 2.

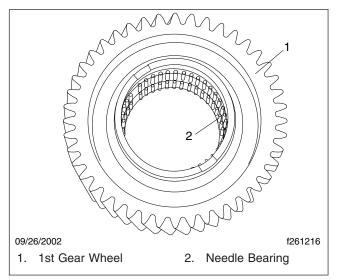
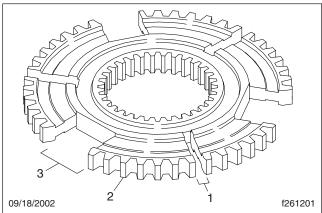


Fig. 2, 1st Gear Wheel and Needle Bearing

- 4. Remove the 1st gear inner synchro cone.
- Remove the 1st gear synchro ring.
- 6. Remove the 1st gear outer synchro cup.

Second Gear

- Remove the 1st/2nd gear synchro slide collar carefully from the synchro body.
- 2. Remove the compression springs and spring holders from the synchro body. Remove the synchro body from the main shaft. See **Fig. 3**.
- Using snap ring pliers, remove the 2nd gear snap ring from the synchro body. Measure the snap ring thickness and record it. Discard the snap ring after recording its thickness. See Fig. 4.
- 4. Remove the synchro body from the main shaft.
- 5. Remove the 2nd gear outer synchro cup.
- Remove the 2nd gear synchro ring and inner synchro cone.
- 7. Remove the 2nd gear driver, wheel, and needle bearing. See **Fig. 5**.



NOTE: The mounts of the 2nd gear outer synchro cup must engage in the large recesses in the synchro body.

- Slot for Compression Spring
- 2. Tooth Flank
- 3. Large Recess

Fig. 3, 1st/2nd Gear Synchro Body

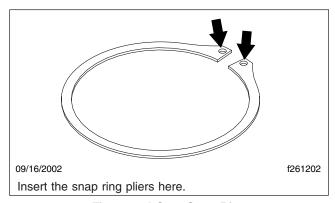


Fig. 4, 2nd Gear Snap Ring

Reverse, First, and Second Gear Disassembly

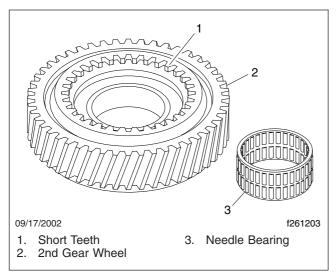


Fig. 5, 2nd Gear Wheel and Needle Bearing

Countershaft Removal and Installation

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools for Countershaft Removal and Installation					
Tool	Description	Manufacturer	Part Number		
f580392	Main Shaft/Countershaft Lifting Device	Kent-Moore	J-46729		
f580395	Main Shaft/Countershaft Stand	Kent-Moore	J-46732		

Table 1, Special Tools for Countershaft Removal and Installation

Removal

- Remove the front gear case. For instructions, see Subject 150.
- Remove the rear gear case. For instructions, see Subject 160.
- Remove the reverse gear and the 1st gear from the main shaft. For instructions, see Subject 170.
- 4. Remove the 2nd gear from the main shaft. See **Subject 170** for instructions.
- Attach the main shaft/countershaft lifting device to the input ends of the main shaft and countershaft. For more information about the special tool, see **Table 1**. See **Fig. 1** for the countershaft with the tool installed.
- Attach a hoist to the ring of the lifting device. Lift the two shafts in the air.
- 7. Remove the main shaft/countershaft stand.
- 8. Remove the bolt attaching the lifting device to the main shaft. Carefully separate the countershaft gears from the main-shaft gears. See Fig. 2.

- Replace the main shaft on the main shaft/ countershaft stand, with the output end down. See Table 1.
- 10. Remove the lifting device from the countershaft.

NOTE: Do not attempt to disassemble the countershaft. If there is damage, replace the entire countershaft. For further disassembly of the main shaft gears, see **Subject 190** and **Subject 200**.

Installation

- Carefully mesh the teeth of the countershaft gears with the teeth of the main shaft gears.
- 2. Lay the main shaft on the bench and attach a hoist or other lifting device to the ring of the lifting device and raise the main shaft off the stand.
- 3. Fasten the countershaft to the lifting device.
- Lower the hoist and place both shafts on the stand. Remove the hoist from the lifting device.
- 5. Install the 2nd gear on the main shaft. For instructions, see **Subject 230**.

Countershaft Removal and Installation

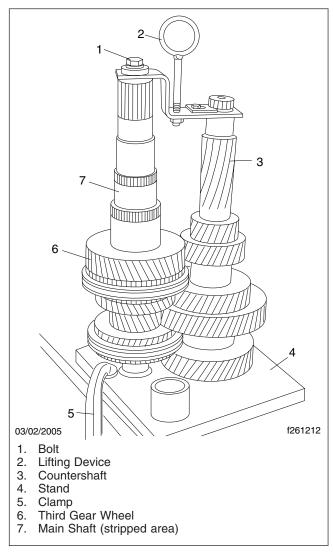


Fig. 1, Countershaft Ready to Remove

- 6. Install the reverse gear and the 1st gear on the main shaft. For instructions, see **Subject 230**.
- 7. Install the rear gear case. For instructions, see **Subject 160**.
- Install the front gear case. For instructions, see Subject 150.

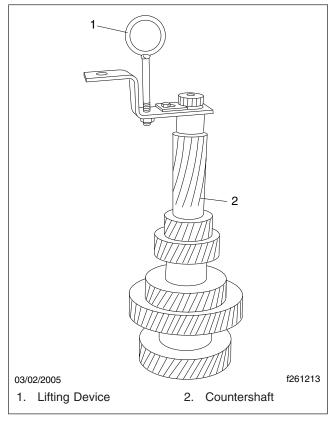


Fig. 2, Countershaft Separated From Main Shaft

Fifth and Sixth Gear Disassembly

Fifth Gear

- Remove the front gear case. For instructions, see Subject 150.
- Remove the rear gear case. For instructions, see Subject 160.
- Remove the reverse gear and the 1st gear from the main shaft. For instructions, see Subject 170.
- 4. Remove the 2nd gear from the main shaft. For instructions, see **Subject 170**.
- 5. Separate the countershaft from the main shaft. For instructions, see **Subject 180**.
- 6. Remove the 5th gear synchro cone and synchro ring from the main shaft.

Sixth Gear

 Carefully remove the 5th/6th gear synchro slide collar from the synchro body. Take care to extract the compression springs and spring holders from the synchro body. See Fig. 1.

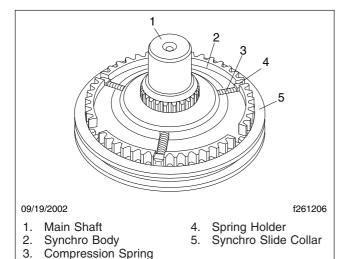


Fig. 1, 5th/6th Gear Synchronizers

- 2. Using snap ring pliers, remove the 5th/6th gear snap ring from the main shaft. Measure the snap ring thickness and record it. Discard the snap ring after recording its thickness. See Fig. 2.
- 3. Remove the 5th/6th gear synchro body from the main shaft.

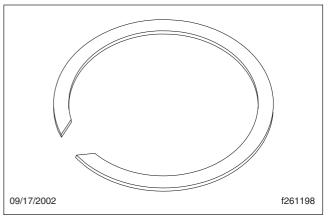


Fig. 2, 5th/6th Gear Snap Ring

- 4. Remove the 6th gear synchro ring and cone.
- 5. Inspect the synchro rings for compliance with the wear limits given in **Subject 240**.
- 6. Remove the 6th gear wheel and needle bearing. See Fig. 3.

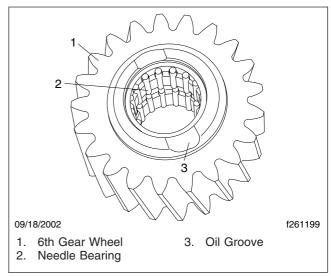


Fig. 3, 6th Gear Wheel and Needle Bearing

Fourth and Third Gear Disassembly

Fourth Gear

- Remove the front gear case. For instructions, see Subject 150.
- Remove the rear gear case. For instructions, see Subject 160.
- Remove the reverse gear and the 1st gear from the main shaft. For instructions, see Subject 170.
- 4. Remove the 2nd gear from the main shaft. For instructions, see **Subject 170**.
- 5. Separate the countershaft from the main shaft. For instructions, see **Subject 180**.
- 6. Remove the 5th and 6th gears from the main shaft. For instructions, see **Subject 190**.
- 7. Using snap ring pliers, remove the 4th gear snap ring from the main shaft. Measure the snap ring thickness and record it. Discard the snap ring after recording its thickness. See Fig. 1.

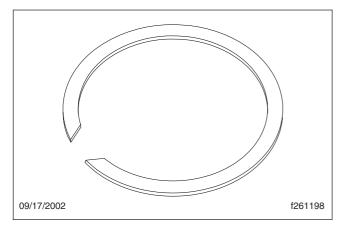


Fig. 1, 4th Gear Snap Ring

- 8. Remove the 4th gear wheel and thrust washer from the main shaft. See Fig. 2.
- 9. Lift the driver off the main shaft.

NOTE: On some models, the driver is welded to the 4th gear wheel.

- 10. Remove the needle bearing.
- 11. Remove the 4th gear inner synchro cone, synchro ring, and outer synchro cup. See Fig. 3.

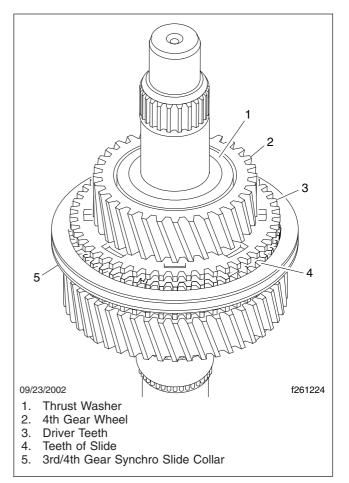


Fig. 2, 4th Gear Synchronizers

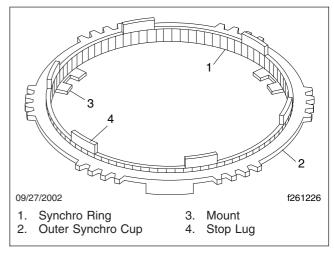


Fig. 3, 4th Gear Synchro Ring and Outer Cup

Fourth and Third Gear Disassembly

Third Gear

 Carefully remove the 3rd/4th gear synchro slide collar from the synchro body. Take care to extract the compression springs and spring holders from the synchro body. See Fig. 4.

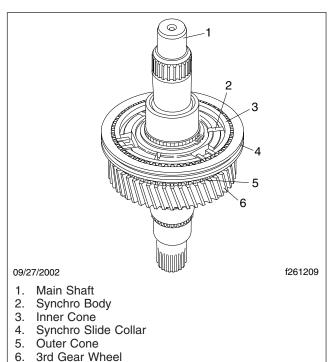


Fig. 4, 3rd Gear Synchronizers

- 2. Using snap ring pliers, remove the 3rd gear snap ring from the synchro body. Measure the snap ring thickness and record it. Discard the snap ring after recording its thickness. See Fig. 5.
- 3. Remove the 3rd gear synchro body from the main shaft.
- Remove the 3rd gear outer synchro cup, synchro ring and inner synchro cone from the main shaft.
- 5. Lift the driver off the 3rd gear wheel.
- Inspect the synchro rings for compliance with the wear limits given in Subject 240.
- 7. Remove the 3rd gear wheel and needle bearing, leaving the main shaft stripped. See Fig. 6.

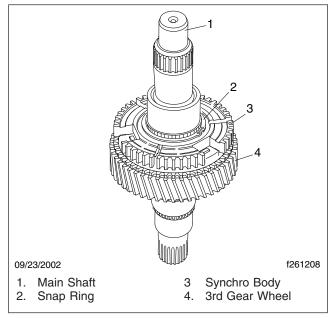


Fig. 5, 3rd Gear Snap Ring

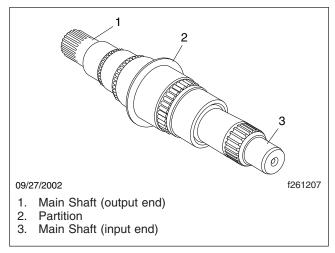


Fig. 6, Main Shaft (stripped)

Third Gear

For an exploded view of this assembly, see Fig. 1.

1. Apply a coating of MobilTrans SHC® DC (the approved transmission oil) to the needle bearing.

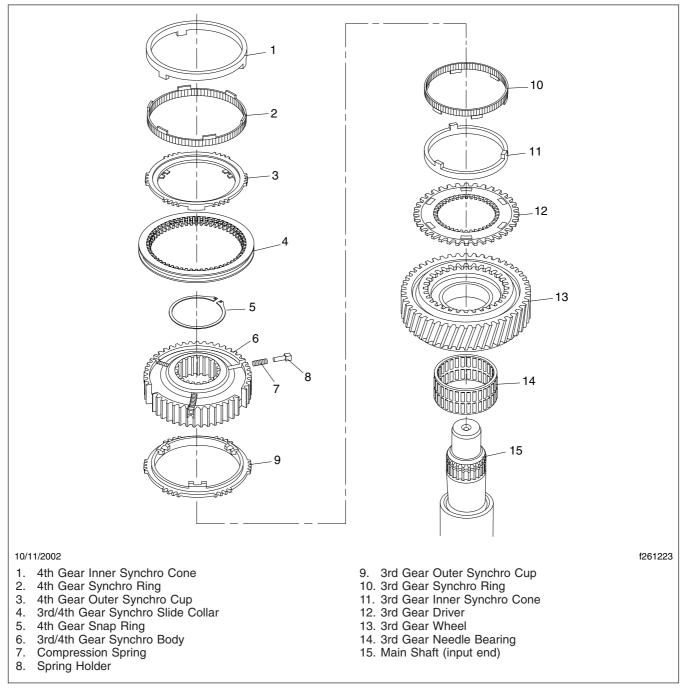


Fig. 1, 3rd Gear Assembly

Fit the needle bearing onto the main shaft. Mount the 3rd gear wheel over the needle bearing with the short splines facing up.

IMPORTANT: When installing the gear wheel, spin it and let it drop. This helps prevent damage to the bearings.

- Place the driver on the 3rd gear wheel with the chamfered teeth facing up.
- Place the 3rd gear inner synchro cone on the driver with the stop lugs facing up.
- 5. Apply a coating of approved transmission oil to the 3rd gear synchro ring. Fit the synchro ring onto the synchro cone with the stop lugs facing down. The stop lugs must engage the slotted holes in the driver.
- Install the 3rd gear outer synchro cup on the synchro ring. The mounts on the outer cup must engage the stop lugs of the inner cone.

NOTE: Make sure the synchro body is installed right side up, with the ridge for the snap ring exposed.

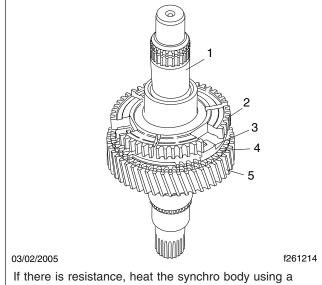
- Fit the 3rd/4th gear synchro body onto the main shaft. If there is resistance, heat the synchro body using a heat gun. The stop lugs of the outer synchro cup must mesh with the large recesses in the synchro body. See Fig. 2.
- Using snap ring pliers, install a new snap ring. Make sure the snap ring is tight when installed, with no free play.

IMPORTANT: If there is free play, remove the snap ring and replace it with a snap ring of the correct thickness to eliminate any free play.

- Install the synchro slide collar on the synchro body as far as the stop.
- 10. Install the three compression springs into the slots in the synchro body. Using a short-bladed screwdriver, press them in until the spring holder engages the tooth of the synchro slide collar. See Fig. 3.

Fourth Gear

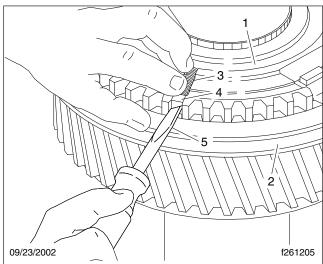
1. Insert the 4th gear outer synchro cup into the synchro body. The mounts of the outer cup must engage with the recesses in the synchro body.



heat gun.

- 1. Main Shaft
- Synchro Body
- 3. Stop Lug
- 4. Driver
- 5. 3rd Gear Wheel

Fig. 2, Fitting the Synchro Body

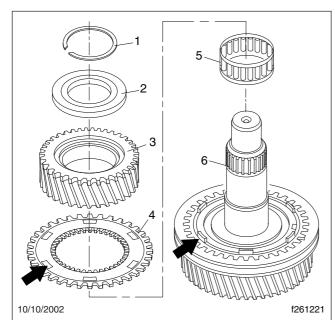


Press in the compression spring until the spring holder engages the tooth of the synchro slide.

- Synchro Body
- Synchro Slide Collar
- Compression Spring
- Spring Holder
- Short-Bladed Screwdriver

Fig. 3, Pressing in the Compression Springs

- 2. Apply a coating of approved transmission oil to the 4th gear synchro ring. Mount the synchro ring on the outer cup with the stop lugs facing up.
- 3. Slide the 4th gear inner synchro cone into the synchro ring with the stop lugs down. The stop lugs of the inner cone must fit into the mounts on the outer cup.
- 4. Apply a coating of approved transmission oil to the needle bearing. Fit the needle bearing onto the main shaft.
- 5. Mount the driver on the main shaft. The asymmetrical tooth tips must face down and the stop lugs up. See **Fig. 4**.



Mount the 4th gear driver with the asymmetric tooth tips facing down and the stop lugs up.

- 1. 4th Gear Snap Ring
- 2. Thrust Washer
- 3. 4th Gear Wheel
- 4. Driver Teeth
- 5. Needle Bearing
- 6. Main Shaft (output end)

Fig. 4, 4th Gear Assembly

6. Mount the 4th gear wheel on the driver. Make sure the slots in the 4th gear wheel engage the stop lugs on the top of the driver.

7. Heat the thrust washer to 176°F (80°C). When heated, press it into the main shaft.

NOTE: Before installing, test the thickness of the snap ring by inserting it into the gap between the main shaft and the thrust washer.

8. Install a new snap ring inside the synchro body. Make sure the snap ring is tight when installed, with no free play. See Fig. 5.

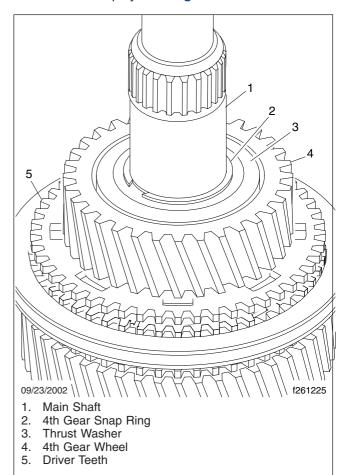


Fig. 5, Snap Ring Installed

- Install the 5th and 6th gears on the main shaft. For instructions, see Subject 220.
- 10. Install the countershaft on the main shaft. For instructions, see **Subject 190**.
- 11. Install the 2nd gear on the main shaft. For instructions, see **Subject 230**.

- 12. Install the reverse gear and the 1st gear on the main shaft. For instructions, see **Subject 230**.
- 13. Install the rear gear case. For instructions, see **Subject 160**.
- 14. Install the front gear case. For instructions, see **Subject 150**.

Sixth and Fifth Gear Assembly

Sixth Gear

For an exploded view of this assembly, see Fig. 1.

1. Apply a coating of approved transmission oil to the needle bearing. Fit the needle bearing onto the main shaft.

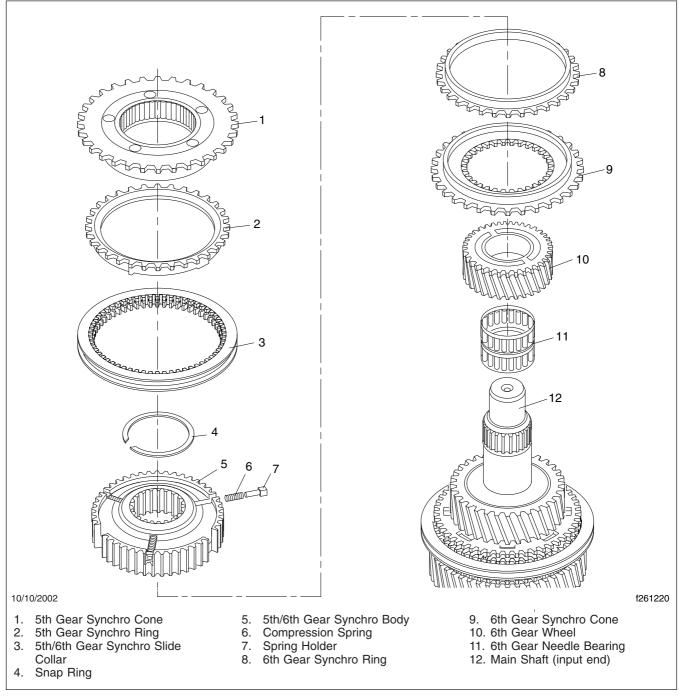


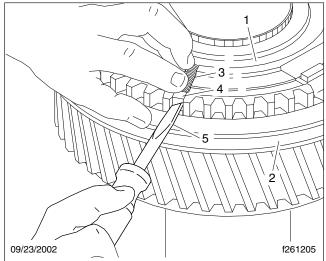
Fig. 1, 5th and 6th Gear Assembly

Sixth and Fifth Gear Assembly

- Mount the 6th gear wheel over the needle bearing with the undercut teeth facing up.
- 3. Install the 6th gear synchro cone. The oil grooves on the synchro cone must align with the oil grooves on the 6th gear wheel. See Fig. 1.
- 4. Apply a coating of approved transmission oil to the 6th gear synchro ring. Fit the synchro ring onto the synchro cone.
- 5. Fit the 5th/6th gear synchro body onto the main shaft. If there is resistance, warm the synchro body using a heat gun. The large stop lugs of the 6th gear synchro ring must mesh with the large recesses in the synchro body.
- 6. Install a new snap ring inside the synchro body. Make sure the snap ring is tight when installed, with no free play.
- 7. Install the 5th/6th gear synchro slide collar on the synchro body as far as the stop.
- 8. Install the three compression springs into the slots in the synchro body. Using a short-bladed screwdriver, press them in until the spring holder engages the tooth of the synchro slide collar. See Fig. 2.

Fifth Gear

- Insert the 5th gear synchro ring into the synchro body. The large stop lugs of the 5th gear synchro ring must engage in the large recesses of the synchro body.
- 2. Insert the 5th gear synchro cone into the 5th gear synchro ring.
- Move the 5th/6th gear synchro slide collar into neutral position.
- Install the countershaft on the main shaft. For instructions, see Subject 180.
- 5. Install the 2nd gear on the main shaft. For instructions, see **Subject 230**.
- Install the reverse gear and the 1st gear on the main shaft. For instructions, see Subject 230.
- Install the rear gear case. For instructions, see Subject 160.
- Install the front gear case. For instructions, see Subject 150.



Press in the compression spring until the spring holder engages the tooth of the synchro slide collar.

- 1. Synchro Body
- 2. Synchro Slide Collar
- 3. Compression Spring
- 4. Spring Holder
- 5. Short-Bladed Screwdriver

Fig. 2, Pressing in the Compression Springs

Second, First, and Reverse Gear Assembly

Second Gear

For an exploded view of this assembly, see Fig. 1.

- 1. Apply a coating of approved transmission oil to the needle bearing. Fit the needle bearing onto the main shaft.
- 2. Mount the 2nd gear wheel over the needle bearing with the short teeth facing up.
- 3. Apply a coating of approved transmission oil to the 2nd gear outer synchro cup and 2nd gear synchro ring. Install the outer cup with the stop lugs facing up. Install the 2nd gear inner ring with the stop lugs facing down and engaging the recesses in the 2nd gear wheel.
- 4. Install the 2nd gear inner synchro cone. The mounts on the synchro cone must engage the stop lugs of the outer cup.
- 5. Fit the 1st/2nd gear synchro body onto the main shaft. If there is resistance, warm the synchro body using a heat gun. The mounts of the 2nd gear outer synchro cup must engage in the large recesses in the synchro body. See Fig. 2.
- 6. Install a new snap ring and press it into place inside the synchro body. Make sure the snap ring is tight when installed, with no free play.
- 7. Install the 1st/2nd gear synchro slide collar on the synchro body with the asymmetric tips of the tooth flanks facing up. See Fig. 3.

IMPORTANT: On each synchro slide collar, there are three shortened tooth flanks, evenly spaced around the perimeter. The shortened tooth flanks of the synchro slide collar should be lined up with the shortened tooth flanks of the synchro body.

 Install the three compression springs into the slots in the synchro body. Using a short-bladed screwdriver, press them in until the spring holder engages the tooth of the synchro slide collar. See Fig. 4.

First Gear

 Install the 1st gear outer synchro cup on the 1st/ 2nd gear synchro body. The mounts of the outer cup must engage in the recesses of the synchro body.

- 2. Apply a coating of approved transmission oil to the synchro ring. Install the ring with the stop lugs facing up. Install the inner cone with the stop lugs facing down and engaging the mounts of the outer cup.
- Apply a coating of approved transmission oil to the needle bearing. Fit the needle bearing onto the main shaft.
- 4. Mount the 1st gear wheel over the needle bearing with the helical teeth facing up.
- 5. Install the inner gear wheel with the rounded teeth facing up.
- 6. Install a new snap ring and press it into place. Make sure the snap ring is tight when installed, with no free play.

Reverse Gear

- 1. Install the reverse gear.
- 2. Install the shift bars and forks.
- Install the rear gear case. For instructions, see Subject 120.
- Install the front gear case. For instructions, see Subject 110.
- 5. Install the shift mechanism. For instructions, see **Subject 100**.

Second, First, and Reverse Gear Assembly

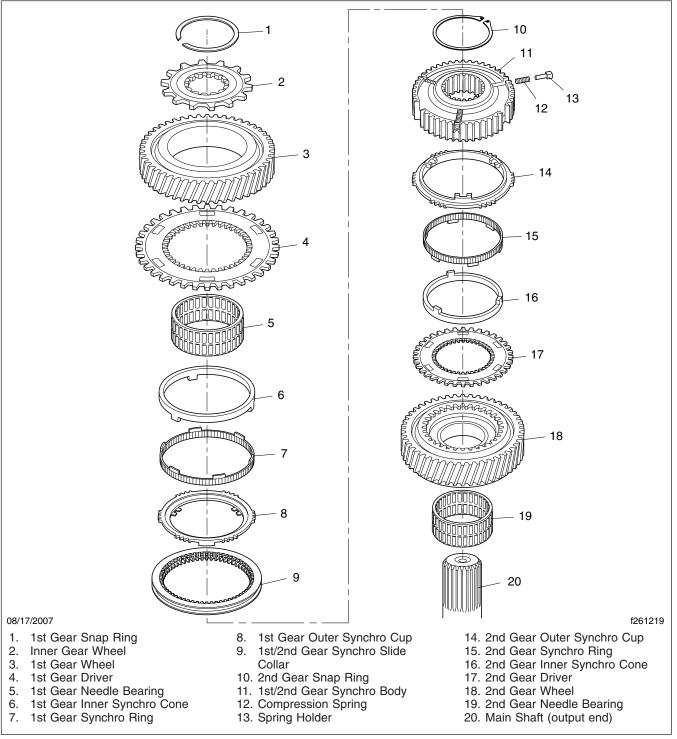


Fig. 1, 1st and 2nd Gear Assembly

Second, First, and Reverse Gear Assembly

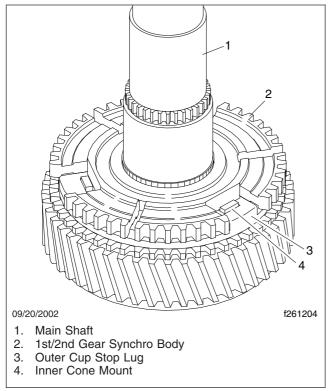


Fig. 2, 2nd Gear Synchronizers

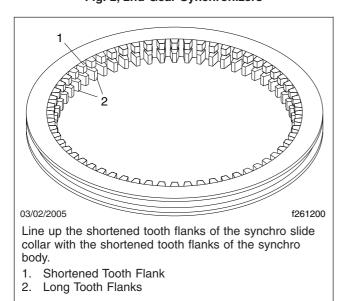


Fig. 3, Synchro Slide Collar

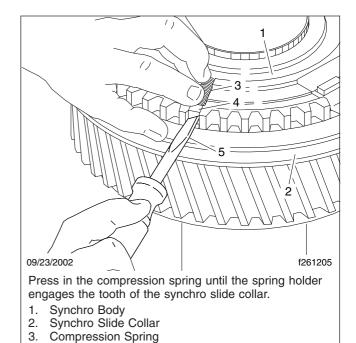


Fig. 4, Pressing in the Compression Springs

Spring Holder

5. Short-Bladed Screwdriver

Synchro Ring Wear Limit Inspection

Special Tools

A special tool is required for this procedure. See **Table 1**.

Special Tool for Reverse, First, and Second Gear Disassembly					
Tool	Description	Manufacturer	Part Number		
f580395	Main Shaft/Countershaft Stand	Kent-Moore	J-46732		

Table 1, Special Tool for Reverse, First, and Second Gear Disassembly

Fifth/Sixth Gear Inspection

- Remove the front gear case. For instructions, see Subject 150.
- 2. Remove the rear gear case. For instructions, see **Subject 160**.
- 3. Remove the reverse gear wheel and needle bearing from the main shaft. For instructions, see **Subject 170**. Do not remove the 1st gear wheel.
- Place the main shaft on the main shaft/ countershaft stand. See Table 1.
- 5. Move the 5th/6th gear synchro slide collar into the neutral position.

NOTE: Do not tilt or twist the synchro ring. This can cause the measurement to be incorrect.

- 6. Put the 5th gear synchro ring into position to measure the 5th gear synchromesh reserve.
 - 6.1 Using the synchro slide collar, push the synchro ring up against the 5th gear synchro cone.
 - 6.2 While pushing the synchro slide collar up, press down on the synchro cone and turn it. Verify that the synchro cup and cone are squarely seated, without sliding into gear.

NOTE: This step requires two persons.

 While one person holds the synchro ring and cone in place, the other person, using a feeler gauge, measures the synchromesh reserve of the 5th gear. See **Table 2** for specified and minimum dimensions.

Synchromesh Reserve, MBT				
Gear Minimum Dimension in inches (mm)		Specified Dimension in inches (mm)		
1st	0.03 (0.7)	0.08 (2.0)		
2nd	0.03 (0.7)	0.08 (2.0)		
3rd	0.03 (0.7)	0.08 (2.0)		
4th	0.03 (0.7)	0.08 (2.0)		
5th	0.02 (0.5)	0.06 (1.5)		
6th	0.02 (0.5)	0.06 (1.5)		

Table 2, Synchromesh Reserve, MBT

- 7.1 Measure the synchromesh reserve over the entire circumference of the ring.
- 7.2 Calculate the average value of the synchromesh reserve.
- 7.3 If the average value of the synchromesh reserve is below the minimum dimension, replace the 5th gear synchro ring.

NOTE: Do not tilt or twist the synchro ring. This can cause the measurement to be incorrect.

8. Put the 6th gear synchro ring into position to measure the 6th gear synchromesh reserve.

Synchro Ring Wear Limit Inspection

- 8.1 Using the synchro slide collar, press the 6th gear synchro ring down against the 6th gear wheel.
- 8.2 While pressing the synchro slide collar down, turn the 6th gear wheel.

NOTE: This step requires two persons.

- While one person holds the synchro ring and gear wheel in place, the other person, using a feeler gauge, measures the synchromesh reserve of the 6th gear. See Table 2 for specified and minimum dimensions.
 - 9.1 Measure the synchromesh reserve over the entire circumference of the ring.
 - 9.2 Calculate the average value of the synchromesh reserve.
 - 9.3 If the average value of the synchromesh reserve is below the minimum dimension, replace the 6th gear synchro ring.

Fourth/Third Gear Inspection

1. Move the 3rd/4th gear synchro slide collar into the neutral position.

NOTE: Do not tilt or twist the synchro ring. This can cause the measurement to be incorrect.

- 2. Put the 4th gear outer synchro cup into position to measure the 4th gear synchromesh reserve.
 - 2.1 Using the synchro slide collar, push the outer synchro cup up against the 4th gear wheel.
 - 2.2 While pushing the synchro slide collar up, turn the 4th gear wheel. Verify that the synchro cup and cone are squarely seated, without sliding into gear.

NOTE: This step requires two persons.

- While one person holds the outer synchro cup and gear wheel in place, the other person, using a feeler gauge, measures the synchromesh reserve of the 4th gear. See Table 2 for specified and minimum dimensions.
 - 3.1 Measure the synchromesh reserve over the entire circumference of the outer synchro cup.

- 3.2 Calculate the average value of the synchromesh reserve.
- 3.3 If the average value of the synchromesh reserve is below the minimum dimension, replace the 4th gear synchro ring.

NOTE: Do not tilt or twist the synchro ring. This can cause the measurement to be incorrect.

- Put the 3rd gear outer synchro cup into position to measure the 3rd gear synchromesh reserve.
 - 4.1 Using the synchro slide collar, press the outer synchro cup down against the 3rd gear wheel.
 - 4.2 While pressing the synchro slide collar down, turn the 3rd gear wheel.

NOTE: This step requires two persons.

- While one person holds the outer synchro cup and gear wheel in place, the other person, using a feeler gauge, measures the synchromesh reserve of the 3rd gear. See Table 2 for specified and minimum dimensions.
 - 5.1 Measure the synchromesh reserve over the entire circumference of the outer synchro cup.
 - 5.2 Calculate the average value of the synchromesh reserve.
 - 5.3 If the average value of the synchromesh reserve is below the minimum dimension, replace the 3rd gear synchro ring.

Second/First Gear Inspection

1. Move the 1st/2nd gear synchro slide collar into the neutral position.

NOTE: Do not tilt or twist the synchro ring. This can cause the measurement to be incorrect.

- 2. Put the 2nd gear outer synchro cup into position to measure the 2nd gear synchromesh reserve.
 - Using the synchro slide collar, push the outer synchro cup up against the 2nd gear wheel.
 - 2.2 While pushing the synchro slide collar up, turn the 2nd gear wheel. Verify that the synchro cup and cone are squarely seated, without sliding into gear.

Synchro Ring Wear Limit Inspection

NOTE: This step requires two persons.

- While one person holds the outer synchro cup and gear wheel in place, the other person, using a feeler gauge, measures the synchromesh reserve of the 2nd gear. See Table 2 for specified and minimum dimensions.
 - 3.1 Measure the synchromesh reserve over the entire circumference of the outer synchro cup.
 - 3.2 Calculate the average value of the synchromesh reserve.
 - 3.3 If the average value of the synchromesh reserve is below the minimum dimension, replace the 2nd gear synchro ring.

NOTE: Do not tilt or twist the synchro ring. This can cause the measurement to be incorrect.

- 4. Put the 1st gear outer synchro cup into position to measure the 1st gear synchromesh reserve.
 - 4.1 Using the synchro slide collar, press the outer synchro cup down against the 1st gear wheel.
 - 4.2 While pressing the synchro slide collar down, turn the 1st gear wheel.

NOTE: This step requires two persons.

- While one person holds the outer synchro cup and gear wheel in place, the other person, using a feeler gauge, measures the synchromesh reserve of the 1st gear. See Table 2 for specified and minimum dimensions.
 - 5.1 Measure the synchromesh reserve over the entire circumference of the outer synchro cup.
 - 5.2 Calculate the average value of the synchromesh reserve.
 - 5.3 If the average value of the synchromesh reserve is below the minimum dimension, replace the 1st gear synchro ring.
- Install the reverse gear wheel and needle bearing on the main shaft. For instructions, see Subject 170.
- Install the rear gear case. For instructions, see Subject 160.
- 8. Install the front gear case. For instructions, see **Subject 150**.

Main Shaft End Play Measurement

Special Tools

Special tools are required for this procedure. See **Table 1**.

Special Tools for End Play Measurement				
Tool	Description	Manufacturer	Part Number	
f580397	Puller/Installer/Stand	Kent-Moore	J-46739	
f580402	Main Shaft End Play Measuring Fixture	Kent-Moore	J-47903	

Table 1, Special Tools for End Play Measurement

Measurement

NOTE: Do this procedure whenever the gear case halves, main shaft, bearings, or input shaft are removed. Perform this procedure with the transmission partially assembled, and with the front gear case removed.

- Place the front case nose down. Install the rear case on the puller/installer/stand, if not already done.
- Set up the main shaft end play measuring fixture on the front gear case with the crossbar flat on the gear case flange and its legs in the air. See Table 1. Lock down the upper thumbscrew at the point where the center shaft of the measuring fixture just touches the contact surface of the input shaft gear wheel. See Fig. 1.
- Turn the end play measuringfixture over and set it up on the rear gear case with the legs down, resting on the gear case flange.

- 4. Lock down the lower thumbscrew at the point where the end cap of the measuring fixture just touches the contact surface of the input shaft mating wheel. See Fig. 2.
- 5. Using a feeler gauge, measure the gap between the shaft and the end cap. This gap is the end play. See **Fig. 3**.
- If the end play is within acceptable limits, continue on to the next step. See Table 2 for acceptable limits.

If the end play is less than the acceptable limit, install a thinner thrust washer and repeat the measurements until the end play is acceptable.

If the end play is more than the acceptable limit, install a thicker thrust washer and repeat the measurements until the end play is acceptable.

Main Shaft End Play Measurement

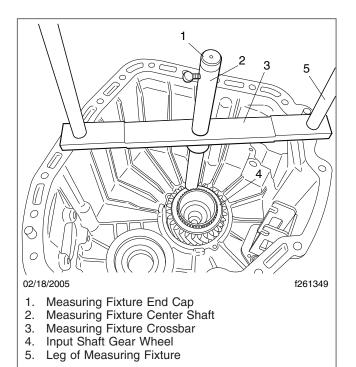


Fig. 1, Taking the First Measurement

Main Shaft End Play Limits				
Model		Maximum Dimension in inches (mm)		
520	0.041 (1.05)	0.049 (1.25)		
660	0.037 (0.95)	0.049 (1.25)		

Table 2, Main Shaft End Play Limits

- Install the input shaft. For instructions, see Subject 120.
- 8. Install the front gear case. For instructions, see **Subject 150**.

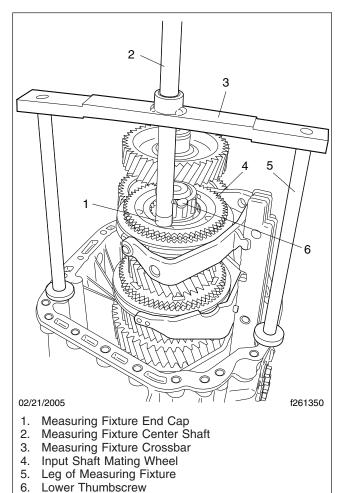
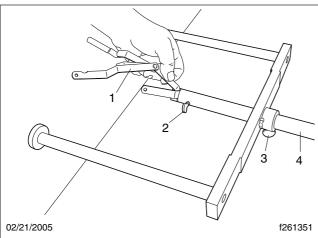


Fig. 2, Taking the Second Measurement

Main Shaft End Play Measurement



Using a feeler gauge, measure the gap (arrow) between the center shaft and the end cap.

- 1. Feeler Gauge
- 2. Lower Thumbscrew
- 3. Upper Thumbscrew
- 4. Measuring Fixture Center Shaft

Fig. 3, Measuring the End Play with a Feeler Gauge

Torque Values, MBT Transmission Removal and Installation				
Fastener	Size	Class	Torque: lbf-ft (N-m)	
Bell Housing-to-Timing Case Capscrews	M10 x 1.5	8.8	33 (45)	
Clutch Slave Cylinder Bracket Mounting Bolts	M8	8.8	15 (20)	
Fuel Cross-Over Line Mounting Bolts	_	_	95 (129)	
Fuel Cross-Over Line Mounting Clamps	_	_	40 (54)	
Midship Bearing Bracket Capscrews	3/4-11	_	95 (129)	
Power Take-Off Unit (PTO) Mounting Capscrews	M10	10.9	43 (58)	
Reverse Gear Switch	M20	8.8	42 (57)	
Shift Lever Mounting Bolt	M10 x 1.5	10.9	50 (68)	
Shift Lever Retaining Ring Screws	_	_	28 (38)	
Speedometer Sensor Lock	M8	8.8	28 (38)	
Starter Lock Switch (optional)	M20	8.8	42 (57)	
Transmission Fluid Drain Plug	M24	8.8	42 (57)	
Transmission Fluid Fill Plug	M24	8.8	42 (57)	
II Joint Find Con Bolto	3/8–24	_	50 (68)	
U-Joint End Cap Bolts	1/2–20	_	110 (149)	

Table 1, Torque Values, MBT Transmission Removal and installation

Torque Values, MBT Transmission Teardown				
Fastener	Torque: Ibf-ft (N-m)			
Clutch Release Fork Mounting Capscrew	26 (36)			
Gear Case Capscrews	22 (30)			
Input Shaft Guide Tube Low-Profile Mounting Capscrew	17 (23)			
Output Shaft Pressure Plate Mounting Capscrew	190 (258)			
Rear Countershaft Cover Capscrew	18 (25)			
Shift Rail Cover Capscrew	29 (39)			
Shift Rail Detent Bolt	22 (30)			
Shift Rod Housing Capscrews	18 (25)			
Shift Rod Setscrew	30 (40)			
Shifter Pin T60 Capscrew (model 660 only)	88 (120)			

Table 2, Torque Values, MBT Transmission Teardown

Gear Ratios			
Model	Gear	Ratio	
	1	9.201	
	2	5.230	
	3	3.145	
MBT520S-6D	4	2.034	
	5	1.374	
	6	1.000	
	R	8.649	
	1	6.700	
	2	3.810	
	3	2.290	
MBT660S-6O	4	1.480	
	5	1.000	
	6	0.730	
	R	6.290	

Table 3, Gear Ratios

Synchromesh Reserve, MBT			
Gear	Minimum Dimension: inch (mm)	Specified Dimension: inch (mm)	
1st	0.03 (0.7)	0. 08 (2.0)	
2nd	0.03 (0.7)	0. 08 (2.0)	
3rd	0.03 (0.7)	0. 08 (2.0)	
4th	0.03 (0.7)	0. 08 (2.0)	
5th	0.02 (0.5)	0. 06 (1.5)	
6th	0.02 (0.5)	0. 06 (1.5)	

Table 4, Synchromesh Reserve, MBT

Main Shaft End Play Limits			
Model	Minimum Dimension: inch (mm)	Maximum Dimension: inch (mm)	
520	0.041 (1.05)	0.049 (1.25)	
660	0.037 (0.95)	0.049 (1.25)	

Table 5, Main Shaft End Play Limits

Special Tools for MBT Transmissions			
Tool	Description	Manufacturer	Part Number
f580389	Synchro Retainer Clips	Kent-Moore	J-46726
f580390	Front Gear Case Bridge	Kent-Moore	J-46727
f580391	Countershaft Guide	Kent-Moore	J-46728
f580392	Main Shaft/Countershaft Lifting Device	Kent-Moore	J-46729
f580393	Snap Ring Removal Tool	Kent-Moore	J-46730
f580394	Reverse Idler Shaft Puller	Kent-Moore	J-46731
f580395	Main Shaft/Countershaft Stand	Kent-Moore	J-46732

Special Tools for MBT Transmissions				
Tool	Description Manufacturer Part Number			
(∂ (∂ () () () () () () () () () () () () ()	Countershaft Retainer	Kent-Moore	J-46733	
f580397	Rear Case Puller/Installer/Stand	Kent-Moore	J-46739	
(b) / f580401	Input Shaft Seal Installer	Kent-Moore	J-47901	
f580398	Output Shaft Seal Installer	Kent-Moore	J-47863	
f580399	Countershaft Seal Cap Installer	Kent-Moore	J-47901	
(f580400	Universal Handle	Kent-Moore	J-8901	

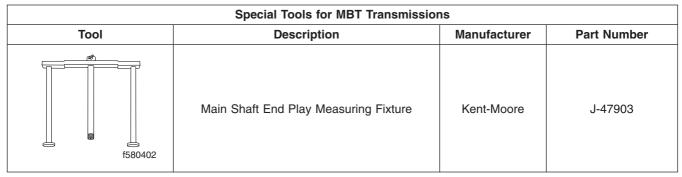


Table 6, Special Tools for MBT Transmissions

Standard Shop Tools for MBT Transmission			
Tool Description Remarks			
Torx® bit set	Must include a size T60 bit		
Inverted-Torx bit set	Must include size E12 and E14 bits		
Large snap ring pliers	Similar to Snap-On p/n PR7		
Large duck-bill snap ring pliers	Similar to Craftsman p/n 9 47386 or Snap-On p/n SRP4		
Seal remover	Similar to Craftsman p/n 9 47645 or Snap-On p/n YA105		
A pair of lifting straps of 300 lb capacity or more	A 1" x 4' loop-type strap handles this unit		
Large soft-faced dead-blow hammer (5-lb. weight)	Similar to Snap-On p/n BC7A		
Large T-bar puller	Similar to OTC p/n 522		

Table 7, Standard Shop Tools for MBT Transmission

Service Material Specifications			
Purpose Product Color			
Thread-locking compound	Loctite® 242 or equivalent	Blue	
Sealant	Loctite 509 or equivalent	Blue to green	
Extreme pressure lubricant	J 23444-A	Dark gray	

Table 8, Service Material Specifications

MBT Transmission Approved Lubricant Type and Capacity			
Transmission Model Lubricant Type Refill Capacity:* qt (L)			
MBT660S-6O	Mobiltrans SHC® DC	9.5 (9.0)	
MBT520S-6D	Widdilitans Show DC	9.5 (9.0)	

^{*} Quantities listed are approximate. Fill the transmission until the lubricant is level with the bottom of the fill hole, with the vehicle in normal operating position.

Table 9, MBT Transmission Approved Lubricant Type and Capacity

Contents

Subject	Subject Number
General Information	
Specifications	400

General Information

A hybrid electric vehicle (HEV) has both a diesel engine and an electric motor. The electric motor is powered by high-voltage batteries, which are charged by regenerative braking and, on vehicles equipped with the ePTO option, the diesel engine. With regenerative braking, when the service brake is depressed (or when the accelerator pedal is at idle while coasting), the vehicle's kinetic energy is captured and stored in the high-voltage batteries. When the batteries are fully charged, regenerative braking is disabled.

Hybrid Electric and Cooling Systems Overview

Eaton Corporation developed and supplies the hybrid electric system for Freightliner Trucks. The primary system components are the hybrid drive unit (or "HDU", which includes the electric generator/motor and automated transmission), Power Electronics Carrier (or "PEC", which contains the high-voltage, lithium-ion batteries), and the inverter (which changes DC to AC, and AC to DC). Electric Power Take-Off (ePTO) and auxiliary power generator (APG) components are optional on the HEV system. For more information on the hybrid electric system, see Eaton's website, www.roadranger.com.

The hybrid electric system has its own liquid cooling system for the motor, inverter, DC/DC Converter (if ePTO equipped), and APG (if equipped). The system includes a radiator and fan, pump, reservoir, and plumbing that are separate from the engine cooling system. See **Fig. 1**. For coolant, it uses a mixture of 50 percent ethylene glycol and 50 percent water.

Safety Features

The HEV has high-voltage cables and a service switch on the PEC. The high-voltage cables are covered in orange insulation and conduit. High-voltage components are tagged with a warning or danger label.

IMPORTANT: The service switch on the PEC should only be used for an emergency shutdown or when the troubleshooting guide or service manual calls for work on the high-voltage system. The troubleshooting guide and service manual for the hybrid electric system are available from www.roadranger.com.

The red service switch is located next to the highvoltage cable connections at one end of the PEC. Push in the red service switch and shut down the engine. The hybrid system will be disabled, and the high-voltage batteries in the PEC, though still live, are isolated in the PEC.

NOTE: The PEC may be mounted in an area with limited access.

Vehicles with the ePTO option are designed with a safety switch to ensure the diesel engine does not start when the hood is open.

Safety Precautions

The HEV has high-voltage components, including 340-volt DC batteries and a 500-volt AC motor. Never cut high-voltage cables or connectors. Do not paint high-voltage cables.

Avoid direct pressure wash on high-voltage connections (PEC, DC/DC Converter) and the air intake and exhaust on the PEC.

Emergency Shutdown

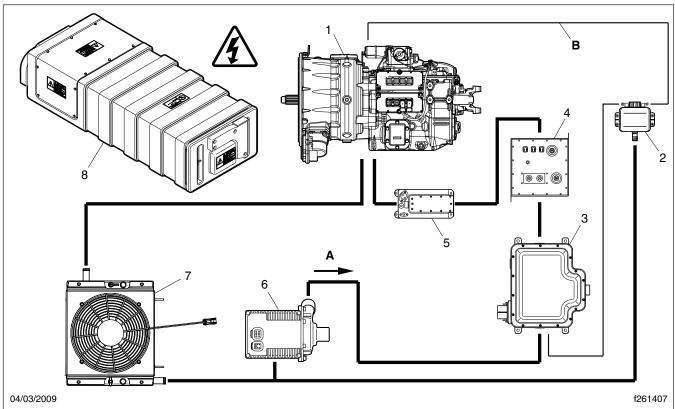


After disabling the vehicle, power is maintained in the high-voltage electrical system for up to five minutes. Unprotected contact with any "live" high voltage components can cause serious injury or even death.

There are two options for performing an emergency shutdown. The preferred method is to turn off the ignition key. The other option is to disconnect the low-voltage (12-volt) vehicle batteries. In either case, the engine will shut down, dash lights will shut down, the hybrid electrical system will shut down, and the high-voltage batteries in the Power Electronics Carrier (PEC) will remain "live" but isolated in the PEC.

NOTE: In an emergency, if the service switch on the PEC is accessible, it may be pushed in to shut down the hybrid electrical system and isolate the "live" HEV batteries in the PEC.

General Information



- A. Direction of flow.
- B. Installed on vehicles December 2008 and later.
- 1. Hybrid Drive Unit (HDU)
- 2. Coolant Reservoir
- 3. Inverter
- 4. Auxiliary Power Generator (optional)

- 5. DC/DC Converter (ePTO vehicles only)
- 6. Coolant Pump
- 7. Hybrid Cooler and Fan
- 8. Power Electronics Carrier (air-cooled)

Fig. 1, HEV Electric and Cooling Systems

In Case of a Fire or Accident

If the HEV becomes involved in an accident or fire, be aware of the following.

- Use CO2 or dry chemical extinguishers. The batteries in the power electronics carrier (PEC) are lithium ion.
- Do not cut into high-voltage cables. The highvoltage wiring is covered in orange insulation or convoluted tubing and marked with warning labels at the connectors.
- Do not cut into or open the PEC.
- Do not cut into or open the DC/DC converter.

Do not cut into or open the inverter.

Hybrid Electric Vehicle 26.05

Specifications

Torque Values, Hybrid Electric Vehicle	
Description	Torque: Ibf·ft (N·m)
Capscrews, Bell Housing to Flywheel Housing	35–45 (47–61)

Table 1, Torque Values, Hybrid Electric Vehicle

NOTE: Torque values for components of the hybrid electric system are available from Eaton. For more information, see Eaton's website, **ww-w.roadranger.com**.