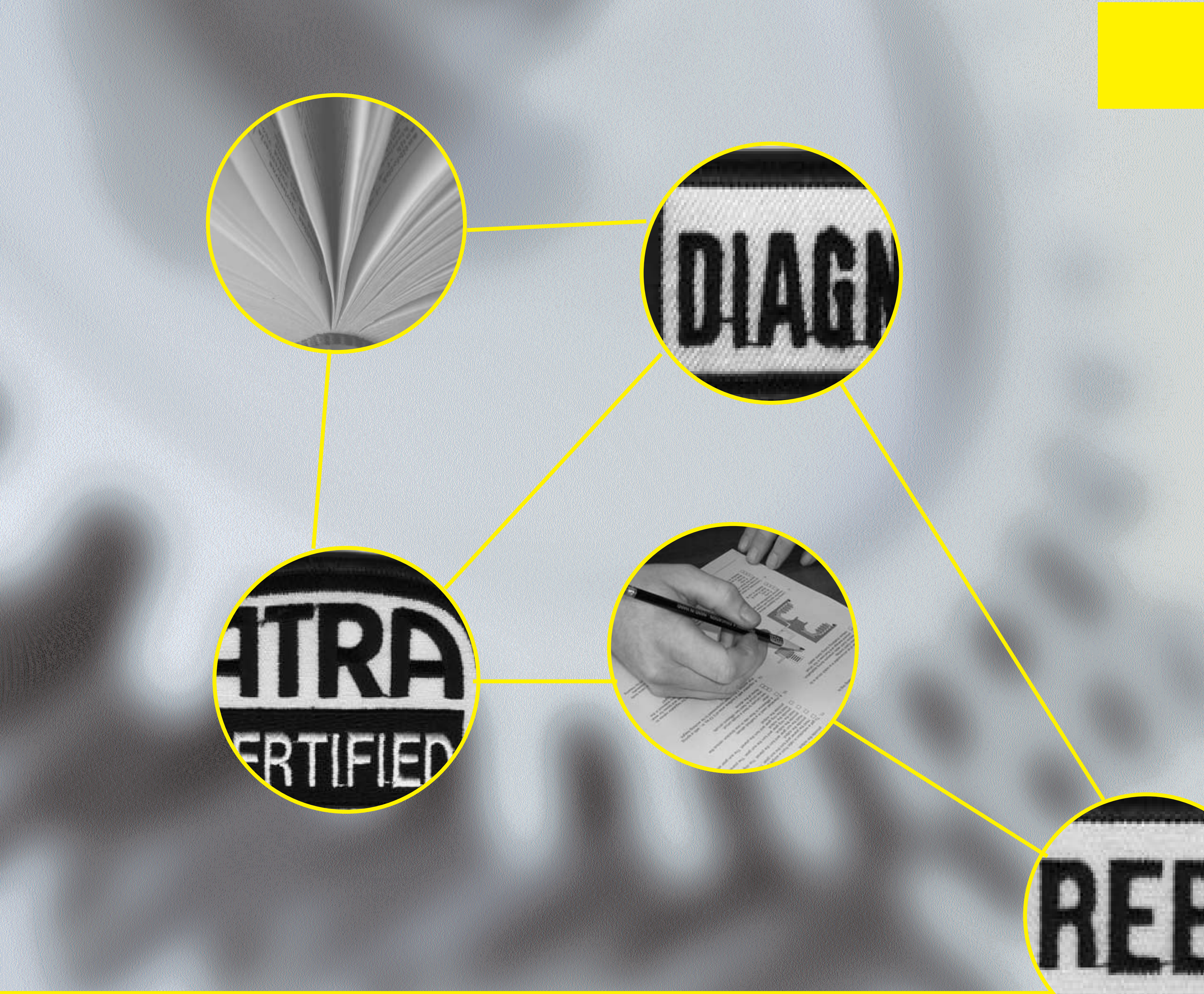

Test Preparation Guide

ATRA
AUTOMATIC TRANSMISSION REBUILDERS ASSOCIATION

service | quality | success

ATRA Certification Prep Guide

Contents

Program Introduction

Welcome to the ATRA Certification Prep Guide! This guide was developed to help you recognize any weaknesses in your technical understanding of automatic transmissions, so that you could focus your studies to help you pass the ATRA Certification program.

But even more than that, its ultimate goal is to help you improve your overall understanding of automatic transmissions, to help you do a better job where it counts: in the shop.

A look at the contents page might lead you to believe that this is a complete transmission training program. It isn't. The information here is generally brief, and was created strictly to offer an overview on the subject matter. The idea was to help you recognize the issues considered important for diagnosing and repairing today's transmissions. If you're comfortable with your understanding of those issues, you should have no problem with the ATRA Certification Test, or with the day-to-day requirements of your work in the shop.

On the other hand, if you find yourself unfamiliar with some of the information here, you owe it to yourself to dig deeper, to learn more about that subject, until it's a part of your basic understanding of transmission technology.

To aid you in that quest, there are a number of specialized manuals available through the ATRA BookStore, including:

- *Hydraulic FunDamentals* by Dennis Madden
- *Road Testing for Results* by Dennis Madden
- *Building Blocks of Electrical Diagnosis* by Steve Bodofsky

And don't forget to look through the back issues of *GEARS Magazine*, available on line at www.atra.com. Virtually all of the concepts discussed in this guide have been covered in depth in *GEARS*.

Once you have a strong understanding of these concepts, you should have no problem passing the ATRA Certification… or with your regular work in the shop.**Transmission Theory**

"I don't care how the transmission works; I just want to know how to fix it!" Too many transmission technicians share this point of view. It's a mistake… and a costly one at that.

Failure to understand the principles behind transmission operation puts them at the mercy of the manufacturer or another information source. Since they don't understand how the transmission is supposed to work, they can never analyze a problem on their own. They only chance they have to solve a transmission problem is if someone else has seen it, and can tell them what to replace. That's not a technician: That's a parts changer.

Because of their lack of understanding, they'll sell more unnecessary work, and waste more time on problems than a technician who can understand and reason out those problems. They'll depend largely on technical hotlines to bail them out when they get in over their heads.

Any diagnostic procedures they perform will be hit-or-miss, rather than targeted to the condition, based on a logical approach to the problem. And it'll show up in their bottom line.

This is why it's so important to understand not just how to fix a transmission, but how it's supposed to work. With that knowledge, you'll run into fewer problems, and you'll be better able to isolate and diagnose them when they do show up.

Mechanical Theory

Every transmission has one, simple purpose: To send torque from the engine to the wheels.

Of course, the torque required varies with driving conditions: From a stop, you need more torque and less speed to get the car moving forward. At highway speeds you need less torque and more speed.

To accommodate the constant changes in torque demand, the transmission offers different gear ratios. Lower gear ratios provide more torque and less speed, while higher ratios offer less torque and more speed.

Most manual transmissions create these different gear ratios by using different gear sets for each gear ratio.

In low range, the drive gear will be very small, while the driven gear will be large. This allows the drive gear to turn more times than the driven gear, providing more torque and less speed.

In higher gear ranges, the drive gear will be larger than the driven gear. The drive gear turns fewer times than the driven gear, so you get less torque and more speed.

At one point, usually third gear, the drive and driven gear are the same size. Both turn the same number of times, creating a one-to-one (1:1) ratio. This is called direct drive. Many manual transmissions don't even use gears for direct drive: They just lock the input shaft to the output shaft.

Automatic transmissions don't have separate gears for each range. Instead, they use gearsets, consisting of a sun gear, a planetary assembly, and a ring gear. By holding one component and turning another, you create a gear range.

For example, if you hold the planetary assembly and turn the sun gear, the ring gear provides an output ratio; the specific ratio depends on the number of teeth on each component of the planetary gearset.

By turning any two components together, the planetary gearset is locked into direct drive.

Gear Ratios

Gear ratios are calculated by dividing the output gear by the input gear. In a common differential arrangement you'll divide the ring gear by the pinion. So a differential with a 60-tooth ring gear and a 20-tooth pinion will have a 3:1 gear ratio. This means the pinion will turn three times for every time the ring gear rotates once.

Planetary gear ratios follow the same rules but the math is a bit more complicated. There are a few rules that all planetary geartrains follow. There are three components to a common planetary gear set: The planet itself, a sun gear, and a ring gear.

To achieve an overdrive ratio, the planet becomes the input and either the sun gear or ring gear is held stationary. The most common application uses a stationary sun gear; the output is the ring gear.

To achieve gear reduction, the planet provides the output. As is the case with the overdrive arrangement, one of the other components (sun gear or ring gear) is held stationary. The remaining component is the input.

Reverse is accomplished by holding the planet. Either the ring gear or sun gear can provide the input. The remaining gear will provide the output.

Clutches and Bands

So how do we hold and turn different components in the gearset? This is where the clutches and bands come in. These are friction components that are splined to connect to various components in the gearset. By applying and releasing the clutches or bands, the transmission can hold or turn different parts of the gearset.

Clutches can either be *driving* components or *holding* components. As a driving component, the clutch is connected to the input shaft, rotating with the torque converter. When applied, the driving clutch rotates a geartrain component.

A holding clutch is connected to the transmission case. When it applies, it holds the component from rotating.

Bands are always holding components; bands and holding clutches are sometimes called *brakes,* because they brake the component rather than drive it.

Clutches and bands are controlled with a pressurized fluid; the transmission hydraulic controls direct the fluid to the clutch piston or band servo. The pressurized fluid forces the piston or servo to apply, causing the clutch or band to squeeze against the mating components. This is called *applying* the clutch or band.

A third type of holding component is the one-way clutch, which will usually be either a sprag or roller clutch. These devices allow a component to rotate one way but not the other, similar to a ratchet. One-way clutches don't have to be applied; they're always on. One-way clutches are only useable where the component is only supposed to rotate in one direction; never in the other.

Torque Converters

The torque converter is an advanced type of fluid coupling that connects the engine and transmission. This fluid connection allows you to come to a full stop without mechanically disengaging a clutch; the slip in the torque converter lets the engine keep running, even though the wheels are fully stopped.

The three main components in a torque converter are the impeller, the turbine and the stator.

The impeller is connected directly to the engine crankshaft; the turbine connects to the transmission input shaft. When the engine is running, the impeller picks up the transmission fluid and slings it into the turbine. This fluid movement gets the turbine spinning, which provides the torque to drive the transmission input shaft.

As the oil passes through the turbine, it enters the stator. The stator is a locked set of fins that redirects the oil, so that it flows in the same direction as impeller rotation. This keeps fluid exiting the turbine from dragging against the converter, and is what makes the torque converter efficient.

The stator is splined to the stator support through a one-way clutch. If the one-way clutch breaks free, the vehicle will lose power on acceleration. If the clutch seizes, the vehicle will seem to drag or hold back at highway speeds.

Most torque converters today include a lockup clutch. This clutch applies when the vehicle load is low and the road speed is high, locking the engine and transmission together. This eliminates any slip between the engine and transmission. While this does improve gas mileage slightly, the primary reason for the torque converter clutch is to prevent heat from being generated in the torque converter. A failed or disconnected converter clutch will often cause the transmission to overheat and fail.

Overview of Transmission Operation

The hydraulic system of an automatic transmission begins with the pump and main regulator. The pump and main regulator provide pressure for converter charge and geartrain lube, as well as all other hydraulic circuits that eventually control the friction elements for each gear range.

The main regulator output is determined by the working area of the valve and the tension of the spring. Most systems also incorporate some type of boost system to vary line pressure based on engine load, usually through a boost valve or by varying balance pressure on the regulator.

Shift and engagement feel are largely determined by line pressure, but are also determined by accumulators, feed orifices, friction material, steel plate surface area, fluid type, cushions in the drums or servos, and clutch apply timing. Higher line pressure provides firmer clutch engagement.

Hydraulic Controls

Most transmissions control clutch apply and shifts through a series of valves. These valves control fluid flow through the transmission.

It starts with the manual valve, which redirects mainline pressure based on the gear range selected. That fluid applies the initial clutches for first gear or reverse. From there, a series of shift valves determines the specific gear range, based on road speed and load.

Early, fully-hydraulic transmissions used a governor to provide a road speed signal, and a throttle valve (TV) to provide a load signal. Pressure from the governor would increase with vehicle speed.

That governor pressure would apply to one side of the shift valve, while throttle pressure would apply to the opposite side, backing up the shift valve spring. When governor pressure overcame the combination of the shift valve spring and TV pressure, the shift valve would stroke. This redirected oil pressure to the clutches or bands necessary for the transmission to shift into the next gear range.

Virtually all of today’s transmissions are controlled electronically. The vehicle computer measures road speed using a vehicle speed sensor (VSS), and engine load by measuring engine vacuum or flow through the intake manifold. The computer then determines the transmission shift points, and controls the shifts by energizing or de-energizing a series of solenoids. These solenoid usually supply pressure to the shift valves, stroking the valves and shifting the transmission.

Some computer systems also control mainline pressure through a solenoid, by creating a pulsed, duty-cycled signal to adjust the position of the solenoid pintle. This creates a metered leak in the pressure from the pump, controlling mainline pressure.

For a more detailed view of transmission hydraulic operation, pick up a copy of *Hydraulic FunDamentals*, available from the ATRA BookStore.

Checkballs and Orifices

Feed orifices control the rate that oil flows to a shifting element, such as a clutch or band. In almost all cases, the feed orifice will be located in the valve body separator plate. In simplest terms, increasing the size of the orifice makes the clutch apply firmer, while decreasing the orifice makes the apply softer. There are other considerations regarding orifice size, but this is a generalization of its function.

Checkballs are commonly found in most automatic transmissions. There are two common applications: bathtub and orifice. A checkball in a bathtub allows two circuits to feed a common element or other system by sealing off the circuit that isn't in use.

An orificing checkball is part of a shift-feel system that forces oil through an orifice in a separator plate while the oil flow moves in one direction. When the oil flows in the opposite direction, it pushes the checkball off its seat, allowing full flow through the separator plate.

Accumulators

Accumulators work like a controlled leak, lowering pressure to the shifting element while the accumulator is moving. Accumulator speed is controlled by a spring, combined in many cases with pressure that's applied to a contained area of the accumulator piston. Regardless of what's used to control the accumulators speed during the shift, one common rule applies: The faster an accumulator strokes during the shift, the softer the shift will be. The slower the accumulator strokes during the shift the firmer the shift will be.

Changing the spring tension on an accumulator will change shift feel (softer or firmer). The effect of the change in spring tension depends on which side of the accumulator the spring resides:

If the accumulator compresses the spring during the shift, a heavier spring will make the shift firmer.

If the spring relaxes during the shift, a heavier spring will make the shift softer.

One contradiction to this is if the accumulator strokes too fast; the shift may not complete until the accumulator bottoms out, at which point all accumulation stops and you get a bump at the end of the shift. This is commonly referred to as a *slide-bump shift* and is often misdiagnosed as a harsh shift.

Shift Feel and Shift Timing

Friction material, drum or steel plate surface, and ATF type can have a major effect on shift quality. Chatters, slide-bumps, and harsh engagements and shifts can all be attributed to these components. The only way you can affect friction material and ATF type is to use the right (or wrong) frictions or ATF for the application.

For a number of years, many technicians sanded the steel and drum surfaces to affect shift quality. This isn't a good idea; not only will sanding the contact surfaces reduce the life of the friction material, but it can cause adverse shift quality conditions.

In most cases, you should replace the steel plates with the frictions; in some cases you'll be able to get away with reusing the old steel plates without sanding them. Always check the drum surface where the band rides: It should be straight and smooth. If it's worn or damaged, replace the drum.

Formulas

You can determine the output pressure of a simple regulator by dividing spring force (at working height) by the working area of the regulator valve. So, a pressure regulator valve with a working area of 0.250" and a 10 lb spring will create an output of 40 PSI (10 ÷ 0.25 = 40).

Electrical Systems Operation

The introduction of electrical controls to transmission operation has created an entirely new set of requirements for today's transmission technician. It's no longer enough to understand how the valves or clutches work; you need to understand advanced electrical concepts.

These concepts include:

- Current flow
- Pulse width modulation and duty cycle
- AC generation
- Hall Effect
- Ohm's Law

… and many more.

What's more, many of the testing procedures have changed. Gone is the simple test light and analog volt-ohmmeter: Today's technician needs to be versed in using a digital multimeter, and preferably a lab scope to measure the variety of signals in today's transmission control circuits.

Overview of Electrical Controls

While each manufacturer has its differences, most of today's electronically controlled transmissions have one thing in common: They use a series of solenoids to control shift operation. And those solenoids are controlled by a computer, which creates its signals based on inputs from various sensors around the vehicle.

In general, those sensors provide the same signals for transmission operation as were used in the older, hydraulically controlled transmissions: vehicle speed and engine load.

The computer then uses those signals to control the solenoids that control transmission operation. In most cases those solenoids include:

- Shift solenoids — open or close to control a hydraulic signal to operate the shift valves.
- Pressure control solenoids — variable bleed solenoids controlled by a variable electrical current. As current increases, pressure decreases.
- Shift modification solenoids — these vary widely based on manufacturer. Some override pressure control during the shift to provide smoother shift feel. Others adjust shift overlap, or prevent conflicting clutch application.

A number of manufacturers are now controlling the clutch apply circuit directly through the solenoids, instead of using the solenoid to operate a shift valve. This system first appeared on Chrysler's 41TE, and is slowly becoming a trend in transmission control.

Solenoids are nothing more than an electrically-controlled valve. When current is flowing to the solenoid, the solenoid energizes; when the current is off, it de-energizes.

Some solenoids are normally closed; that is, the valve is closed when the solenoid is de-energized, and opens when current is flowing.

Other solenoids are normally open; the valve is open when the solenoid is de-energized, and closed when current is flowing.

Pressure control solenoids are always normally closed; they bleed off pressure as current applies. The more current applied, the more pressure they bleed off. When the solenoid is de-energized, the solenoid closes, keeping pressure at maximum. This is done to make sure, if the computer or circuit loses power, the transmission operates at high pressure, so it won't burn up.

The control signal to the pressure control solenoid is a duty cycled signal. That is, it's a pulsed signal with a constant frequency. What changes is the ratio of signal on-time to off-time. A 50% duty cycle signal is on half of the time and off half of the time. A 75% duty cycle signal is on $3/4^{th}$s of the time, and off $1/4^{th}$ of the time. The number of pulses per second remains the same, regardless of conditions.

Electrical Formulas and Principles

There are a number of important principles you'll need to be familiar with when diagnosing electrical circuits. Of these, probably the most important are Kirchhoff's Laws of Current and Voltage, and Ohm's Law.

Kirchhoff's Law of Voltage — Voltage drop in a circuit will increase proportionately with resistance. When added together, the sum of the voltage drops in a circuit will equal the voltage drop for the entire circuit. There will be no voltage left over.

It's this law that provides us with the basis for the voltage drop test. And it proves that, if you see any voltage on the ground side of a circuit, it means there's unwanted resistance in that circuit.

Kirchoff's Law of Current — The total current that goes into a junction is equal to the total current that comes out of a junction. There is no extra current, and none is lost.

This is the law that provides us with the basis for being able to measure current anywhere in a circuit, as the current will be the same whether we measure it at the positive post of the battery, the negative post, or anywhere in between.

Ohm's Law — The current in a circuit is directly proportional to the applied voltage, and inversely proportional to the circuit resistance.

This is the law that gives us the direct relationship between volts, amps and ohms, and proves that, if we know any two values in a circuit, we can easily determine the third:

Amps x Ohms = Volts

Volts ÷ Amps = Ohms

Volts ÷ Ohms = Amps

For an in-depth look at these laws and how they affect electrical diagnosis, pick up a copy of *The Building Blocks of Electrical Diagnosis* from the ATRA BookStore.

Basic Electrical Test Procedures

There are several electrical test procedures you should be familiar with to diagnose today's electronically-controlled transmissions:

Voltage Check

Measuring the voltage between two points in a circuit. To perform a voltage drop check:

- Connect your meter's negative lead to the negative-most part of the circuit.
- Connect your meter's positive lead to the positive-most part of the circuit.
- Set your meter to measure volts.
- Read the voltage measurement on the display.

Voltage Drop Test

In a voltage drop test, you're looking for any sign of unwanted or unplanned resistance in the circuit. This is based on Kirchhoff's Law of Voltage. To perform a voltage drop test:

- Connect your meter's negative lead to the negative-most part of the circuit.
- Connect your meter's positive lead to the positive-most part of the circuit.
- Set your meter to measure volts.
- Load the circuit to its maximum levels.
- Read the voltage measurement on the display.

By moving the positive probe along the circuit and rechecking the voltage drop, you can pinpoint unwanted resistance in the circuit.

Resistance Test

A resistance test is the measurement of resistance in a circuit or component, measured in ohms. To perform a typical resistance test, you must isolate the circuit or component from the rest of the wiring harness, to prevent a backfeed through the circuit.

- Isolate the circuit from the rest of the wiring harness.
- Make sure the circuit is powered down completely before checking the resistance.
- Set your meter to ohms.

- Connect your meter's leads to one another, and zero the meter (critical on low resistance measurements).
- Connect one meter lead to one end of the circuit; the other lead to the other end.
- Read the resistance on the display.

The one problem with a resistance measurement is most circuits' resistance will change when energized. This is why it's usually preferable to measure circuit resistance indirectly, by measuring voltage and amperage, and calculating resistance using Ohm's Law.

Amperage Test

An amperage test measures the current flow through a circuit. There are two common ways to do this: one is to connect your meter in series with the circuit and measure the amperage directly. A second, easier way is to use a current clamp connected to your voltmeter, which measures the magnetic field around the wire and translates that into an amperage reading.

Frequency Measurement

Frequency is the number of pulses or cycles in an electrical circuit every second, measured in Hertz (Hz). A measurement of one Hertz is one cycle per second; 100 Hz is one hundred cycles per second, and so on.

To measure the frequency of a signal:

- Connect your meter negative lead to a good ground.
- Connect your meter positive lead to the signal wire.
- Set your meter to measure frequency.
- Read the frequency measurement on the display.

Duty Cycle Measurement

A variable duty cycle signal is a pulsed signal that varies the duration of on-time relative to the length of a complete cycle. So if the signal is on half the time and off half the time, the duty cycle is 50%. If it's on 3/4^{ths} of the time and off 1/4th of the time, it has a duty cycle of 75%. How you connect your meter to measure the duty cycle depends on whether the circuit is ground controlled or feed controlled.

Most digital meters provide a duty cycle measurement capability. But some duty cycled signals aren't simply on-off signals; many are current limiting. A common example is the pressure control signal on a KM transaxle. The only way to measure these signals accurately is with a scope.

Overview of Computer Controls

The computer system that controls today's transmissions operates based on a series of inputs from around the vehicle. These inputs come from switches or sensors, and provide the computer with the data it needs to control engine and transmission operation. In most cases you'll need a scan tool to gather diagnostic trouble codes and monitor switch and sensor circuit information.

The manual lever position (MLP) sensor provides a digital signal that indicates the gear selector position. The manual lever position sensor is actually a series of switches that creates a pattern of on and off signals to the computer. From those signals the computer can determine the exact gear range the driver has chosen.

Pressure switches either complete or open an electrical circuit. These switches open or close based on applied pressure; they either ground a circuit to operate a specific device, or they open or close to provide a signal to the computer. In early TCC controls, a grounding switch was tapped into governor pressure to energize the TCC solenoid when governor pressure was high, indicating vehicle speed was high enough to handle lockup. Other grounding type switches are used to tell which gear is operating or to operate the backup lights.

A *potentiometer* is a type of computer sensor. Rather than opening or closing a circuit, a potentiometer controls the circuit voltage by varying its resistance. A throttle position sensor (TPS) is a potentiometer. It sends very low voltage to the computer when the throttle is closed; the voltage signal increases as the throttle opens. Other potentiometers may include the MAP, vacuum or BARO sensors. Most potentiometers receive a reference voltage of 5 volts.

Vehicle speed sensors provide road speed to the computer. There are several types of speed sensors:

- Alternating Current (AC) generators
- Reed-style mechanical sensors
- Hall Effect sensors
- Optical sensors
- Magnetoresistive sensors

Regardless of the type of sensor, each of these sensors creates a voltage signal that varies with vehicle speed. The computer uses this signal to measure vehicle speed, to control transmission shift patterns and lockup operation.

Temperature sensors are usually thermistors: electronic devices that change resistance based on temperature. Most are negative temperature coefficient (NTC) thermistors; that is, their resistance goes down as temperature increases. The computer uses temperature sensor signals to vary engine and transmission operation based on temperature.

Code Checks

Most computer system diagnoses begin with checking for diagnostic trouble codes (DTC). These codes indicate computer system failures that the computer has identified, and can help you target your diagnosis more accurately.

In most cases you'll need an up-to-date scan tool to read and clear diagnostic trouble codes. Very few systems are left that allow you to short a terminal and count the flashes.

There are several important things to remember about codes:

1. Codes don't necessarily indicate a faulty component. For example, while a TPS code *could* indicate a bad TPS, it might just as easily indicate a problem in the TPS circuit, or sometimes even in an unrelated circuit that shares a common ground. Always use the codes to direct your diagnosis; never assume the diagnosis based on the code.
2. Codes can be either hard or soft. Hard codes indicated problems that are there now, and will reset the code repeatedly. Soft codes are those that are stored in memory, and may indicate an intermittent problem, or even a problem that was repaired without clearing the codes.

This is why, whenever you're checking the computer system, you should:

- Check and record any codes in memory.
- Clear the codes.
- Drive the vehicle again, and see if any codes reset.

Any codes that reset indicate hard codes, which should be fairly easy to track down and diagnose. Codes that don't reset may be either intermittent problems, or they may not be there at all: Someone may have corrected the problem and just forgot to clear the code.

In either case, keep the codes on record, and explain the situation to the customer. Ask him to pay attention to the driving conditions if the malfunction indicator lamp (MIL) comes on again, to help you diagnose the problem.

Inside or Outside?

The key to transmission diagnosis today can be summed up in three words: inside or outside? Is the problem inside the transmission, or outside, somewhere in the rest of the vehicle? This should be your first consideration during any transmission diagnosis.

To determine whether you're looking at an internal or external problem, you'll usually require three basic test procedures:

1. Check the computer codes.
2. Check the computer control signals to the transmission.
3. Try to shift the transmission with a shift controller.

If the signals to the transmission are okay, but the transmission isn't working properly, there's a good chance you're looking at an internal problem. To reinforce that, you'll want to try to force the shift using replacement signals from a shift controller. If the transmission still won't shift, you can be fairly certain the transmission is at fault.

If the transmission shifts properly from the shift controller, but the signals from the computer aren't correct, more than likely you're looking at a computer system problem. Always take care of those problems before removing the transmission for repair.

There is one condition that can cause some difficulty here: Some internal problems can affect the signals to the computer system. These include problems with speed sensors, pulse generators, pressure switches and so on.

If the transmission has a problem that affects these signals, it may prevent the transmission from operating properly from the computer system, but still seem to shift using a shift controller. In that case, you may still be dealing with an internal problem, and have to remove the transmission to repair the problem.

Diagnostic Strategies

Customer Contact

One of the most important steps in any diagnosis is verifying the complaint; you can identify and repair a hundred different problems, but if you didn't fix the customer's complaint, you didn't fix the car.

The customer walks through the door, and says, "I'd like to have my car's transmission serviced." Sounds simple enough, doesn't it? You write up the car, and send the customer on his way.

Not so fast: Before you accept any service work from a customer, the first question that should come to mind is, "why?" Why does the customer want his transmission serviced? Is it just time, or is there a problem he's hoping a service will correct?

This is a critical consideration, because once you perform the service, any problems with that transmission are yours… at least, in the customer's mind. As far as he's concerned, you did the service, and he has a problem. The fact that the problem was there before the service quickly fades from memory.

Once you've discovered why the customer's there, next you need to determine when and where that problem shows up. You can use a simple acronym to learn the details of just about any diagnostic problem: **TAC — Time, Action** and **Conditions**:

Time is basically how long the car's been driving before the problem shows up. Does it begin as soon as you start the car? After you've been driving it for awhile? How long? Does it ever go away? How long do you have to drive before it goes away?

Action is what was taking place when the problem appears. Accelerating or decelerating? Constant cruise? During a shift? Climbing or going down a hill? Turning? Braking?

Conditions are whatever's happening around the car when the problem occurs. Is it hot or cold out? Sunny or rainy? Windy? How about the traffic; is it light or heavy? Is the car loaded down or is the customer the only one in the car?

Some of this information might have absolutely no bearing on the diagnosis. But sometimes even the most obscure tidbit can provide a real clue as to the cause of the problem.

Visual Inspection

One of the first steps in examining any vehicle problem is to perform a visual inspection. Look for anything obvious …anything out of the ordinary. Many problems will require an in-depth diagnosis; others will jump right out at you.

You'll be amazed at the number of times you can correct a problem simply by repositioning the floor mats, or removing some debris that's sitting on the intake manifold, blocking the throttle linkage.

Other types of obvious conditions might include a wire or connector that's become disconnected, and is just hanging off in space. Or a crimped cooler line, or even a wiring harness that was caught between the bellhousing and the block.

Many a repair has been avoided by a simple visual examination… and many a transmission has been disassembled for no reason, because someone forgot to have a look around first.

Fluid Level and Condition

Low fluid levels can cause low pressures, which will cause a slip between shifts. Check the fluid condition while checking the fluid level. Examine the fluid carefully.

If the fluid's low, the problem could be a leak. Check the transmission case, sump and cooler lines for evidence of leaks. If the transmission uses a vacuum modulator, check the vacuum line for signs of fluid; the modulator diaphragm may be leaking fluid and into the vacuum line. From there, the engine will suck the fluid into the engine, burning away all evidence of the leak.

The normal color of automatic transmission fluid (ATF) varies by manufacturer. If the fluid is dark brown or black and has a burnt odor, the fluid overheated.

A milky color indicates engine coolant has been leaking into the transmissions cooler in the radiator. While a rebuild will be necessary, it's critical to repair the source of the coolant leak, or the problem will just be repeated.

After checking the fluid level and color, wipe the dipstick with a white paper towel and check the residue:

- Dark particles are normally band and clutch material.
- White, silvery particles are normally caused by worn metal parts, such as the pump or clutch drums.
- Brass or bronze metal particles indicate worn bushings or thrust washers.

If you can't wipe the dipstick clean, it's probably coated with varnish caused by fluid oxidation. Varnish or other heavy deposits indicate the need to change the transmission fluid and filter. Severely varnished fluid may indicate the transmission is worn out and needs to be rebuilt.

Low fluid levels can cause a variety of problems. Air can be drawn in the oil pump's inlet circuit and mixed with the fluid. This will aerate the fluid, causing slow pressure buildup and low or erratic pressures, which will cause a slip between shifts. Air in the pressure regulator valve will cause a buzzing noise when the valve tries to regulate pump pressure.

Excessively high fluid levels can also cause aeration. As the planetary gears rotate in high fluid levels, air can be forced into the fluid. Aerated fluid can foam, overheat and oxidize. All of these problems can interfere with normal valve, clutch and servo operation. Foaming may be evident by fluid leaking from the transmission vent.

Linkage and Vacuum Controls

Mechanical or vacuum control problems can contribute to shift problems. Always check the condition and adjustment of the various linkages and cables whenever you're faced with a shift problem.

Make sure the manual and throttle linkages or cables are adjusted properly. Look for any worn bushings or pivots that can affect adjustment or travel. Even a small amount of wear can have a dramatic effect on transmission operation.

Work the throttle linkage or cable all the way through its travel; look for any sign of binding or kinks. Make sure the linkage returns all the way to its at-rest position, without having to push it back into place.

On vehicles that use a modulator, a problem in the modulator or its vacuum source can cause upshifts to occur at the wrong speeds or not occur at all. Make sure you have the proper modulator on the vehicle, and that the vacuum hose and line are in good condition, without any kinks or cracks that could affect the vacuum source.

If the vacuum readings at the modulator are normal, it indicates there are no vacuum leaks in the line and the engine is in satisfactory condition.

If you find transmission fluid in the vacuum line to the modulator, the vacuum diaphragm in the modulator is leaking; replace the modulator. To verify this, apply a vacuum to the valve with a handheld pump. The valve usually won't hold vacuum if the diaphragm is leaking. If the problem seems to be modulator-related but the vacuum source, vacuum lines, and vacuum modulator all check out okay, the modulator may need to be adjusted.

Check Computer Codes

The next step in any transmission diagnosis should be to check the computer system for codes. These codes can help you identify computer system problems that can be directly related to transmission problems.

In most cases you should be able to verify a code by checking the signal from the indicated circuit through your scan tool. For example, a vehicle speed sensor code could easily indicate a problem that affects transmission operation.

Record all codes in memory, then clear the codes and see if any return. If the code returns immediately, it means you're dealing with a hard code; that is, a condition that's there now, and should be easy to trace and diagnose.

Codes that don't return could be residual memory, from a problem that was corrected before, or they could be soft codes. Soft codes indicate intermittent problem that aren't there right now. They may be difficult to find until they return.

Road Tests

Assuming the vehicle drives, the next step in the diagnosis should be to perform a diagnostic road test. This is where you drive the vehicle and try to verify the customer's complaint.

In most cases, you'll want to monitor the computer signals to the transmission, and keep an eye on certain computer system operation during your road test. For this, you'll need a signal monitor connected to the transmission solenoid control wires and a scan tool.

Try to duplicate the customer's complaint while driving the vehicle and monitoring the computer signals. The object is to see whether the problem is inside or outside the transmission; that is, whether it's being caused by a transmission problem (inside) or a computer system problem (outside).

If the signals are correct but the condition persists, the problem will usually be internal. If the signals aren't correct while the problem occurs, look for an external cause.

Pinpoint Diagnostic Procedures

Diagnostic trouble codes don't necessarily mean a component needs replacement. They're strictly an indication of a problem in one of the computer circuits. Once you have a code, you still need to identify the specific failure. That's where pinpoint diagnostic procedures come in.

A code may indicate the signal voltage is below range for a sensor or component. It could be due to a bad sensor, or it could be because of a loose or corroded connection in the sensor feed, sensor ground, or the signal wire. Or maybe there's a short in one of the circuits. Or a misadjusted component. Any of these conditions can pull the sensor signal below range.

This is where pinpoint diagnosis comes in. The code was just a pointer, indicating which circuits to check. From there you have to check signal voltages and circuit resistances, to identify the root cause of the failure.

The most important consideration is understanding the circuits: How they're wired, how they work, and what type of signal you should expect when they're working correctly. From there you can work out exactly what type of checks and tests will reveal the source of the problem.

Pressure Tests

In some cases, a pressure test will be a valuable tool for identifying specific transmission problems. This test allows you to measure the fluid pressure in the different transmission circuits during various operating gears and gear selector positions. The number of hydraulic circuits that can be tested varies with each make and model.

Most transmission problems can be identified without conducting a pressure test, so you should never begin your diagnosis with a pressure test. A pressure test has its greatest value for diagnosing rough shifts or improper shift timing. Both of these problems may be caused by excessive line pressure, which can be verified by a pressure test.

During a road test, observe the starting pressures and whether the pressure increases steadily with slight increases in engine load. Pay attention to how much the pressure drops as the transmission shifts. On most units, the pressure shouldn't drop more than 15 PSI between shifts, and should recover as soon as the shift is complete.

Any pressure reading that isn't within specifications indicates a problem:

- If pressures are low, look for an internal leak, a clogged filter, low oil pump output, or a faulty pressure regulator valve.
- If pressure increases at the wrong time or the pressure isn't high enough, look for sticking valves or leaking seals.
- If the pressure drops more than 15 PSI between shifts, look for an internal servo or clutch leak.

To get to most out of a pressure test, begin by measuring mainline pressure in all gear ranges and at three basic engine speeds: idle, medium throttle, and wide-open throttle (WOT). If the pressure in all operating gears is within specifications at idle, the pump and pressure regulators are working fine. If all pressures are low at idle, look for a problem in the pump, pressure regulator, filter, fluid level, or an internal pressure leak.

To identify the problem further, check the pressure in the various gears at medium throttle. If the pressures are within specifications, the problem is usually a worn oil pump, but it may be an internal leak. Internal leaks are often more evident in a specific gear range because that's when ATF applies the leaking circuit. If there's a leak in a particular clutch circuit, pressure will drop in that gear range, or when the transmission operates in that gear.

You can learn even more by observing the pressure change at wide-open throttle in each gear range. A clogged oil filter will normally cause a gradual drop at higher engine RPM, because the fluid can't pass through the filter fast enough to keep up with the pump.

If the pressure doesn't change with the increase in engine RPM, look for a stuck pressure regulator, which allows pressure to build with increased engine RPM, but won't provide the necessary boost pressures.

If the pressures are high at idle, look for a faulty pressure regulator or throttle valve problem.

If pressures are low at WOT, pull on the throttle valve (TV) cable or disconnect the vacuum hose to the modulator (where applicable). If this causes the pressure to rise to normal, the low pressure is caused by a faulty cable or a problem in the vacuum modulator or vacuum lines. If the pressures remain below specifications, the most likely cause is the pump or control system.

If all pressures are high at WOT, compare the readings to those at idle. If they're high at idle and WOT, look for a problem in the pressure regulator or throttle system.

If the pressures are normal at idle and high at WOT, look for a problem in the throttle system.

To verify a weak or worn oil pump, perform a stall test in reverse. If the pressures are low during this test but normal during all other tests, suspect a weak pump.

Stall Test

A basic stall test involves locking the brakes, putting the transmission in gear, and momentarily opening the throttle all the way. Keep in mind that a stall test is only valid if you know the converter stall speed for that vehicle and engine. If the torque converter has been replaced, your results may be meaningless.

CAUTION: Never hold the stall test for more than three seconds, to prevent overheating the transmission.

If the torque converter and transmission are functioning properly, the engine will reach the specified RPM. If the tachometer indicates a speed above or below specification, it indicates a possible problem in the transmission or torque converter. If you suspect a torque converter problem, you should remove it and check the stator one-way clutch with the converter on the bench.

If the stall speed is below specifications, suspect a restricted exhaust or slipping stator clutch. If the stator one-way clutch isn't holding, fluid leaving the turbine works against the rotation of the impeller and slows the engine. With either of these problems the vehicle will exhibit poor acceleration, either because of lack of power from the engine or because there's no torque multiplication from the converter.

If the stall speed is only slightly below normal, the engine probably isn't producing enough power and should be diagnosed and repaired.

If the stall speed is above specification, the bands or clutches in the transmission may be slipping.

If the vehicle has poor acceleration but had good stall test results, suspect a seized one-way clutch. Excessively hot fluid is a good indication of a seized one-way clutch, but other problems can cause these same symptoms, so be careful during diagnosis.

A normal stall test will generate a lot of noise, most of which is normal. But if you hear any metallic noises during the test, diagnose the source of these noises first. Operate the vehicle at low speeds on a lift with the drive wheels free to rotate. If the noises are still present, the source of the noise is probably the torque converter. The converter should be removed and bench tested for internal interference.

Converter Clutch Testing

Nearly all late-model transmissions are equipped with a lockup torque converter. Most of these lockup converters are controlled by a computer. In most cases, the computer energizes the converter clutch solenoid, which opens a valve and allows fluid pressure to engage the clutch. Be careful diagnosing these lockup systems, because poor lockup clutch action can be caused by problems in the engine, electrical system, clutch, or torque converter.

The key to diagnosing a lockup converter clutch is a thorough understanding of how the system operates. Many of today's vehicles use a pulsed solenoid to modify apply pressure and control converter clutch apply. Without a clear picture of the specific wiring and operation, you won't be able to diagnose the converter clutch operation accurately.

Lockup clutch engagement should be smooth. If the clutch engages early or isn't receiving full pressure, you could experience a shudder or vibration caused by the clutch rapidly grabbing and slipping. The clutch begins to lock and then slips because it can't hold the engine's torque to complete the lockup. The capacity of the clutch is determined by the oil pressure applied to the clutch and the condition of the friction surfaces of the clutch assembly.

If the shudder is only noticeable during lockup clutch engagement, the problem is typically in the converter. When the shudder is only evident after the engagement, suspect a problem in the engine, transmission, or another driveline component.

Identifying the source of the shudder can be difficult, because the torque converter clutch tends to load the engine, so many ignition misfires only occur when the converter clutch is applied. One way to identify whether you're dealing with a converter clutch shudder is to add a friction modifier to the transmission fluid; if the shudder feels different after adding the friction modifier, the problem is probably in the converter clutch.

When converter clutch apply pressure is low and the clutch can't lock firmly, it'll cause a shudder. This may be caused by a faulty clutch solenoid valve or its return spring. The valve is normally held in position by a coil-type return spring. If the spring loses tension, the clutch will be able to engage prematurely. Since there's insufficient pressure available to hold the clutch, the clutch begins to grab and slip, creating a shudder. If the solenoid valve or return spring is faulty, you'll need to replace it along with the torque converter.

All torque converter clutch (TCC) control tests should begin with a basic inspection of the engine and transmission. Apparent transmission and torque converter problems are often caused by engine mechanical problems, broken or incorrectly connected vacuum hoses, or improper ignition timing or idle speed.

Once you've established the problem is in the TCC, perform a basic inspection of wires and hoses; look for burnt spots, or bare, damaged or pinched wires. Make sure the harness to the computer has a tight, clean connection.

Check the source voltage at the battery before beginning any detailed test on any electronic control system. If the voltage is too low or high, the electronic system won't function properly.

On early TCC-equipped vehicles, lockup was controlled hydraulically. A switch valve was controlled by two other valves. The lockup valve responded to governor pressure and prevented lockup at speeds below 40 MPH (64 km/H). The failsafe valve responded to throttle pressure and permitted lockup only in high gear. Poor converter clutch operation could be caused by engine, electrical, clutch, or torque converter problems.

The converter clutch on later vehicles is almost completely electronically controlled. The computer operates a solenoid that controls hydraulic flow through a circuit; that circuit controls a valve, which controls the operation of the converter clutch.

Before the lockup clutch applies, the vehicle must be traveling at or above a certain speed. The vehicle speed sensor (VSS) sends a vehicle speed signal to the computer, which the computer uses to determine when it's time to energize the converter clutch solenoid.

In most cases, the converter clutch isn't supposed to be able to engage when the engine is cold. The engine coolant temperature (ECT) sensor provides the computer with a temperature signal. The computer won't activate the converter clutch solenoid until the engine reaches normal operating temperature.

During sudden deceleration or acceleration, the converter clutch should disengage. One of the sensors used to tell the control computer these driving modes is the throttle position sensor (TPS). Another type of load sensor is the manifold absolute pressure (MAP) sensor, or the mass airflow (MAF) sensor. The computer may use any of these sensor signals to control converter clutch operation.

Some transmissions use a third or fourth gear switch to signal the computer when the transmission is in a high enough range to allow lockup. A brake switch is used in some circuits to disengage the converter clutch when you apply the brakes. Inspecting these key sensors should be part of any converter clutch diagnosis.

Electrical Tests

The first step in any electrical diagnosis should always be to check the battery and charging system. This is the source of all vehicle electricity, so a problem here can affect all other electrical systems.

Start with a visual inspection: Look for damaged or corroded battery terminals, or frayed or loose wires. With the engine off, make sure the alternator belt is in good condition and tightened properly.

Check the battery no-load voltage. A fully-charged battery should deliver 12.6 volts; if it's below 12.4 volts, charge the battery and retest the system before continuing your diagnosis.

If the battery no-load voltage is okay, run a load test. During this test, you should load the battery to one half of its cold cranking amp rating for 15 seconds. During this test, battery voltage shouldn't drop below 9.6 volts at 70ºF (21ºC).

Next you should check the charging system. During this test, you'll check the current and voltage from the alternator during normal operation and under electrical load. In most cases the alternator should deliver between 14 to 15 volts under normal operation, and be capable of producing its full amperage rating with the engine at fast idle and the electrical system loaded.

Don't forget to check the AC voltage signal from the alternator. Excessive AC can create interference in the electrical system, trigger the computer and cause erratic vehicle performance. Anything over about 500 millivolts AC indicates a problem in the alternator, and requires further diagnosis.

Finally, you should run a starter draw test, to make sure the starter circuit is working properly. During this test you'll disable the fuel injection system and crank the engine while monitoring the current draw from the starter. In most cases starter draw should be less than 250 amps, but always check the factory specs to be sure.

Noises and Vibrations

Constant velocity (CV) or universal (U) joints, wheel bearings, and brakes can generate noises that customers mistake for the transmission or torque converter. Check the entire driveline before assuming the noise is transmission-related.

Most transmission vibrations are caused by an imbalanced torque converter assembly, a poorly mounted torque converter, or a faulty output shaft. The key to determining the cause of the vibration is to pay particular attention to the operating conditions that the vibration relates to. In general, the vibration will relate to one of three conditions:

1. Engine RPM — If the vibration changes directly with engine RPM, look for an imbalance in the engine or torque converter. In some vehicles it's possible to isolate the vibration by unbolting the torque converter from the flywheel and starting the engine. If the vibration is still there, it's an engine problem, not a transmission problem.
2. Vehicle Speed — A vibration that changes with vehicle speed is probably due to an imbalance in the wheels or drive train. First thing to suspect is wheel balance. If they're okay, other possibilities include imbalanced brake drums or rotors, or an imbalanced driveshaft or axle shaft. If the vehicle uses a two-piece driveshaft, make sure the universal joints are aligned properly.
3. Vehicle Load — Vehicle load vibrations are usually caused by wear in a driveline component, such as a U-joint or CV-joint. Check for signs of rust around the U-joint caps or a torn CV boot; either can indicate a problem.

Noise problems follow a similar line of thought, with one addition: gear range. If the noise changes with gear range, it's probably due to a problem inside the transmission. To diagnose these problems, it's important to be aware of which components rotate in which gears.

If the noise relates to engine RPM and is present in all gears, including park and neutral, the most probable source is the pump or torque converter, because they rotate whenever the engine is running. But you must be familiar with the transmission to make this diagnosis: Some transmissions, such as the Ford AOD and the early VW AG4, spline the torque converter directly to a clutch drum, which rotates with the crankshaft. The bearings on these drums can create a noise that's easy to mistake for a converter noise.

If the noise relates to engine RPM, and is present in all gears except park and neutral, look for a problem in those parts that rotate in all gears, such as the drive chain, the input shaft, and the torque converter. Often the exact cause of the noise and vibration can only be identified through careful inspection of a disassembled transmission.

Finding and Repairing Leaks

One of the more common types of transmission problems you're likely to face is leak repair. Usually the difficulty with leaks isn't the actual repair: it's finding the leak that's a problem.

That's because the leaking fluid blows back across the transmission while the vehicle is in motion, soaking everything in its path. This makes it hard to identify exactly what leak to fix.

Very often transmission technicians address this by simply recommending a complete external reseal. This isn't as irresponsible as it may sound at first, because in most cases all of the seals are the same age and have experienced the same conditions. So if one is leaking, it's just a matter of time before the others begin to leak.

There are several tools or tricks you can use to help find transmission leaks. One manufacturer offers a smoke machine. The transmission fills with smoke, so you can see where the smoke is leaking out.

Another offers a black light dye that you can add to the transmission fluid. Then you use a black light to find the leak.

A low-tech solution to finding leaks is to wipe down the transmission and spray some silver paint onto the transmission case. Then drive the vehicle. The fresh oil will wash away the silver paint as it leaks, leading you right to the source of the leak.

Don't forget that many leaks only occur under specific conditions, such as when the transmission is hot or you're driving at high speeds. This can make it more difficult to identify the leak.

Another issue that can cause all kinds of leaks is a plugged transmission vent. The vent gets plugged with dirt or undercoating. Then, as the transmission heats up, it builds up pressure inside, pushing the oil past the seals. The fix is simply to clear the vent.

Don't forget to check for any service bulletins when looking for a leak. Very often hard-to-find leaks have been addressed in print, along with the proper fix.

Notes:

Maintenance and In-Car Repair

Manual Linkage and Transmission Range Sensor or Switch

A worn or misadjusted manual linkage will affect transmission operation. The transmission's manual valve must engage the selected gear completely. Partial manual valve engagement won't allow enough pressure to reach the rest of the valve body. If the linkage is misadjusted it can cause poor gear engagement, slipping and excessive wear. The selector linkage should be adjusted so the manual valve detent position in the transmission matches the selector detent and position indicator.

To check the linkage adjustment, move the shift lever slowly, one range at a time, from park to the lowest drive range. You should feel detents at each position as you move the lever. If you can't feel the detent in any of these positions, adjust the linkage.

After adjusting any type of shift linkage, recheck it for detents throughout its range. As a safety measure, make sure you feel a positive detent when you place the shift lever into park. If you're unable to bring the linkage into adjustment, the levers and grommets may require replacement.

Any time you disassemble the linkage from the levers, always replace the grommets that retain the cable or rod. Use a pry tool to force the cable or rod from the grommet, and then cut the old grommet. You can use a pair of pliers to snap the new grommet into the levers, and the cable or rod into the grommet.

Once you have the manual linkage adjusted properly, always check the adjustment of the transmission range sensor or switch. Adjusting the linkage may change the position of the sensor, and cause transmission operating problems.

Some switches have an alignment hole; you put the transmission in neutral, loosen the adjustment bolts, and slide a pin or drill bit into the alignment hole. Then you tighten the adjustment bolts, and remove the pin.

The precise method for adjusting the transmission range switch or sensor varies from vehicle to vehicle, so always check the procedure in your shop manual for the specific vehicle you're working on.

Throttle Valve (TV), Kickdown and Accelerator Pedal Cables or Linkage

The throttle cable or linkage connects the throttle to the TV in the valve body. On some transmissions, the throttle linkage may control both the downshift and throttle valves. Others use a vacuum modulator to control the throttle valve and a throttle linkage to control the downshift valve.

Always check the linkages and cables to make sure they're connected properly and operating freely. Any binding, kinks or looseness in the pivots or connectors indicates a problem that will affect transmission operation.

Later model transmissions may not have a throttle cable. They rely on electronic sensors and switches to monitor engine load and throttle position.

The action of the throttle valve produces throttle pressure. Throttle pressure provides an engine load signal to the transmission, and influences shift speeds and mainline pressure.

A misadjusted TV linkage may keep throttle pressure too low, relative to engine load, causing early upshifts. It can also reduce the clutch holding capacity, which can cause the clutches to slip and burn.

If throttle pressure is too high, it can cause harsh and delayed upshifts, and part-throttle and WOT downshifts will occur earlier than normal. Adjustments as small as half turn can make a big difference in shift timing and feel.

Some transmissions use a kickdown switch, typically located at the upper post of the throttle pedal. Pressing the throttle all the way closes the switch, which signals a forced downshift.

To check the kickdown switch, make sure the engine is off. Press the throttle slowly to the floor, and listen for a click just before the pedal reaches WOT. If you don't hear the click, adjust the switch until the pedal lever makes contact with the switch. If the pedal contacts the switch too early, the transmission may downshift during part throttle operation.

If you hear the click but the transmission still doesn't downshift, check the switch. An open switch will prevent forced downshifts; a shorted switch can cause upshift problems.

Modulator and Hoses

Diagnosing the vacuum modulator begins with checking the vacuum at the modulator. The modulator should receive manifold vacuum. If it does, and there are no vacuum leaks in the line, check the modulator itself for leaks with a handheld vacuum pump.

If there's any transmission fluid in the modulator line, the vacuum diaphragm in the modulator is leaking: Replace the modulator.

If the vacuum source, lines, and modulator are in good condition but shifts indicate a modulator problem, the modulator may need adjusting. The procedure for this varies for each type of transmission. Check your shop manual for the procedure for adjusting the specific modulator you're working on.

Governors

For a hydraulically-controlled transmission to shift, governor pressure must overcome throttle pressure. A transmission that won't shift at all could be caused by a governor problem, assuming the rest of the transmission is okay.

If your tests indicate a governor problem, you should remove, disassemble, clean and inspect it. Some governors are mounted internally, and the transmission must be removed to service the governor. Most, however, can be serviced by removing the extension housing or oil pan, or by removing an external retaining clamp and cover, which provides access to the governor.

On a gear-driven governor, don't forget to check the drive gear, usually mounted to the vehicle output shaft or differential housing. These gears can become loose or damaged, and cause a number of different shifting problems that appear to be a governor problem.

Another area to check is the governor bore or housing. Wear in this area can cause a fluid pressure leak, which can either lower or raise governor pressure, depending on the specific area of the leak. In some cases this type of wear can be repaired by boring out the transmission case and installing a bushing to replace the governor bore surface. If the governor housing is worn, you'll need to replace the housing to eliminate the wear.

In most governors, the weights and springs are calibrated to the vehicle and transmission. Always be careful to use the proper weights and springs when repairing or replacing the governor.

Switches, Sensors and Solenoids

Several sensors and switches provide the computer with information on vehicle operating conditions. Most of these sensors are also used to calibrate engine performance. The computer then determines the appropriate shift time for maximum efficiency and shift quality.

The shift solenoids are controlled by the computer, which either supplies power or ground to energize the solenoids. The techniques for diagnosing electronic transmissions are basically the same as those used to diagnose TCC systems.

Although electronically-controlled transmissions are relatively reliable, they have introduced new problems. Some common problems that affect transmission operation include incorrect battery voltage, a blown fuse, poor connections, a faulty input sensor signal, damaged solenoids, crossed wires to the solenoid or sensors, corrosion at an electrical terminal, or improper installation of an accessory, such as a stereo or GPS module.

Incorrect shift points can be caused by electrical circuit problems, faulty electrical components, bad connectors, or a defective governor or governor drive gear assembly. Most fully electronic transmissions don't have a governor or governor signal; they rely on the electrical signals from electrical sensors to determine shift timing.

External problems can be the result of a compete loss of power or ground to the control circuit or a failsafe protection strategy initiated by the computer to protect the transmission from damage. The default gear is simply the gear that's applied when the shift solenoids are off, usually second gear and reverse.

A visual inspection of the transmission and the electrical systems should include a careful check of all electrical wires and connectors for damage, looseness and corrosion. Loose connections, even when clean, usually only make intermittent contact. They'll also corrode and collect foreign material, which can prevent contact altogether.

Use an ohmmeter or ammeter to check circuit continuity. Check all ground straps to the frame or engine block. This part of your inspection is especially important for electronically-controlled transmissions. Check the fuse or fuses to the control module. To check a fuse accurately, either test it for continuity with an ohmmeter or check each side of the fuse for power.

Service Procedures

The transmission's fluid and filter should be changed whenever there's an indication of oxidation or contamination. Periodic fluid and filter changes are also part of the preventative program for most vehicles. How often you have the transmission serviced depends on the vehicle's normal operating conditions: Severe use requires the fluid and filter be changed more often.

There are two basic types of transmission service available today: the traditional service, which includes removing the pan and replacing the filter, and the complete fluid exchange service. Both have their benefits, and the best way to care for a transmission is to do both.

To perform a traditional service on most transmissions you must remove the oil pan to drain the fluid. Some transmission pans include a drain plug, which makes draining the fluid in the sump easier.

The filter or screen is normally mounted to the bottom of the valve body. Filters are made of paper or fabric and are usually held in place by screws, clips or bolts. As a rule, always replace filters; screens can be cleaned. Remove the screen the same way you would a filter, then clean it with fresh solvent and a stiff brush.

Check the bottom of the pan for deposits and metal particles. Slight contamination or blackish deposits from clutches and bands is normal. Other contaminants could indicate a problem.

Steel particles indicate internal transmission wear or damage. If the metal particles are aluminum, they may be part of the torque converter stator or transmission case. Some torque converters use phenolic plastic stators, so metal particles found in these transmissions must be from the transmission itself.

The problem with the traditional service is that it only drains the fluid in the sump; usually 3 to 5 quarts of ATF. As much as 4 to 7 additional quarts of fluid remains in the converter, clutch drums and servos. You can drain almost all of the fluid if the converter has a drain plug; but those drain plugs are pretty rare on units with a converter clutch.

A fluid exchange service flushes virtually all of the old fluid out of the transmission. This service usually involves disconnecting one of the cooler lines, and using the transmission's natural flow to push the old fluid out, while the service machine pushes new fluid in to take its place.

The downside of the fluid exchange service is that it doesn't require you to remove the pan, so you can't inspect the pan for deposits or replace the filter.

A better service includes a little of both services:

- Remove the pan and examine any deposits
- Wash out the pan
- Replace the filter
- Replace the pan gasket
- Reinstall the pan, and torque the gasket to specs

From there, you perform the fluid exchange service. This allows you to replace all of the fluid, while making sure the transmission is in good shape and replacing the filter.

Always make sure you're using the right filter. Many transmissions have multiple versions, with slightly different filter designs. The differences may include the size of the outlet (where it mounts to the valve body), or the depth of the pickup. While the wrong filter may seem to fit just fine, it can cause transmission problems, or even damage the transmission.

Something else you can do to improve the transmission life is to add an in-line filter to the cooler lines. This provides additional filtering capability, removing more debris from the fluid.

Fluid Types

There are many different types of fluids available on the market today. The most common types include:

Dexron/Mercon — Specified for most GM and Ford vehicles

Highly Friction Modified (HFM) — Provides a different type of friction modification additives than Dexron/Mercon. Used in some Chrysler and many import units.

Synthetic — Usually has similar friction modification characteristics to Dexron/Mercon, but offers better resistance to heat and wear.

And there are a few manufacturers that offer their own, unique fluid types. Always check the manufacturer's recommendations before adding or replacing transmission fluid.

There are a number of additives on the market designed to modify Dexron/Mercon to simulate HFM or other types of fluids. These seem to work well, and many manufacturers approve of their use. But if the transmission is still under a factory warranty, you might be better off using the factory fill.

One thing there's no replacement for is a quality base fill. Many common transmission problems, such as chatters, slide-bump shifts, harsh shifts, etc. can be traced back to using an economy-grade transmission fluid. Some additives can help reduce those effects, but the better solution is to use a good quality transmission fluid to start.

Transmission Adjustments

There are several different types of adjustments necessary for transmissions, depending on the specific unit you're working on. Virtually all transmissions have a manual lever adjustment, designed to adjust the position of the manual lever and manual valve.

Don't confuse the manual lever adjustment with the adjustment for the shift lever indicator. This is a separate adjustment that simply adjusts the position of the indicator on the dash. Always adjust the manual lever first, then adjust the shift lever indicator if necessary.

Some transmissions have a throttle position cable or linkage that must be adjusted for proper transmission operation. The specific procedure varies, and can be very critical. Always check your shop manual or information service for the procedure for the vehicle you're working on.

If the vehicle has a modulator, it may be adjustable. Always make sure the modulator is receiving a good vacuum signal before attempting to alter shift operation with a modulator adjustment.

A few transmissions also have an adjustment for their pressure control valve; on electronic units the pressure control solenoid may be adjustable. Be very careful with these adjustments: a single turn may firm up the shift, but it may also create problems, such as a harsh downshift or a slide-bump in one range.

If you do try to adjust the pressure control valve or solenoid, keep close track of the adjustments you made, so you can return it to the factory setting if necessary.

Band Adjustments

Some transmissions have adjustable bands. If the band is a shifting band, improper adjustment can cause shift timing problems, such as slipping or slide-bump shifts. On holding bands, improper adjustment can cause apply problems, such as harsh applies.

In general, band adjustment is a maintenance item. It should be done as part of normal maintenance or during a rebuild. Once a problem develops, it's usually too late to adjust the bands.

To help identify whether a band adjustment will correct a problem, compare the results of your road test with a clutch and band application chart. If the slip occurs during a gear change that requires the band to apply, tightening the band may correct the problem.

On some vehicles, the bands can be adjusted externally with a torque wrench. On others, the transmission fluid must be drained and the oil pan removed. Still others require special tools, and can only be adjusted by replacing the servo apply pin. In most cases, these bands should be adjusted during a rebuild, and not as part of normal maintenance.

Leak Checking and Repair

Perform a thorough examination for external transmission leaks. Check all seals and gasket areas.

In many cases, transmission fluid leaks will be easy to spot. Correcting the leak will usually involve replacing the damaged or worn seal or gasket. If the front or rear seal is leaking, always replace the bushing at the same time; wear in the bushing allows the shaft to sag and break the seal.

In some cases the leak may be caused by wear on the shaft being sealed. If so, the repair will depend on the specific location of the leak and the degree of damage to the shaft. The repair may involve simply sanding or flat-filing the surface area, installing a wear sleeve, or replacing the shaft altogether.

While most leaks take place at a seal or gasket, some leaks can be caused by cracks, wear or improper casting of the case. You may be able to repair that type of leak with a fast-drying epoxy. If not, you'll have to replace the damaged component.

A common leak is the gasket between the oil pan and the transmission housing. Retorquing the pan bolts may correct this problem. If tightening the pan doesn't fix the leak, you'll need to remove the pan and install a new gasket. Make sure you're using the proper type of gasket for the pan, and the pan's rail is flat and capable of providing a seal before reinstalling it.

An oil leak at the speedometer cable can be corrected by replacing the O-ring seal. While replacing the seal, inspect the drive gear for chips and missing teeth. Always lubricate the O-ring and gear prior to installation.

Extension housings present a number of potential leaks, including the mating surface between the extension housing and the case, the output shaft, the speedometer gear housing, and the governor housing. Addressing leaks in most of these areas is usually straightforward: In some cases it can be as simple as retightening the mounting bolts to factory specs. In other cases, it'll involve removing the component housing, replacing the seal or gasket, and reinstalling the housing in the case.

A leak at the output shaft seal will usually require replacement of the seal itself. But often it'll also require replacing or smoothing the driveshaft yoke, and replacing the output shaft bushing.

When installed in the transmission, the output shaft yoke should have very little side-to-side or up-and-down movement. Too much movement indicates a worn output shaft bushing.

Replacing the bushing is easier than it might appear: There's a special puller designed to thread into the old bushing, and pull it right out of the extension housing. From there, it's easy to install a new bushing, using the proper bushing driver.

Another source of a leak that's easily confused with an output seal leak is a leak at the vent in the yoke. These vented yokes usually have some type of seal between the output shaft and yoke, to prevent too much oil from entering the yoke. If the seal is worn, damaged or missing, excess oil can make its way into the yoke, and actually pump itself out the small vent in the yoke, causing a leak that appears to be from the output shaft seal.

In some cases, leaks can be difficult to pinpoint. In that case, dry the area, and paint it with silver spray paint. Then drive the vehicle until the leak reappears. The fluid will wash the spray paint away, and point right to the leaking component.

Cooling Systems

All automatic transmissions require some type of cooler to remove heat from the transmission. The cooler can either use the engine coolant to remove heat from the transmission fluid, or be air cooled. The specific location of the cooler will vary from vehicle to vehicle. Many are mounted inside one tank in the radiator; one line feeds the heated oil to the cooler, the other allows the cooled oil to flow back to the transmission.

On coolers that share the engine cooling system, proper cooling system operation is critical to the transmission. Failures in the cooling system will affect the transmission long before they become apparent in engine operation or performance. Always inspect the engine's cooling system carefully whenever there's evidence of ATF overheating or a transmission cooling problem.

Leaks in the transmission cooler will usually allow engine coolant into the transmission. Check the dipstick for evidence of coolant mixing with the ATF. Milky fluid indicates that engine coolant is leaking into the transmission and mixing with the ATF. You may also notice ATF in the radiator when you remove the radiator cap, because ATF will float to the top of the coolant.

In most cases, if coolant leaks into the transmission, the transmission will have to be rebuilt. Always replace the cooler and flush the cooler lines before installing the rebuilt transmission.

External cooler leaks result in traces of ATF around the source of the leak. It may take a little time to determine the source of the leak.

It's important to check the cooler flow during every rebuild; inadequate flow will cause the transmission to overheat. With the engine idling, you should have at least 1 quart of flow through the cooler in 20 seconds.

If cooler flow is below specs, you can try flushing it with a cooler flusher. Always recheck the cooler after flushing, to see whether the coolant flow is back to normal. Never use the flusher to check cooler flow: The flushing solvent is less viscous than ATF, and even a plugged cooler will allow more solvent through than ATF. If flushing doesn't bring cooler flow back to specs, replace the cooler.

Check the condition of the cooler lines from one end to the other. Look for signs of damage, cracks, rust or leaks. A damaged line will reduce oil flow through the cooler and shorten the life of the transmission.

If the steel cooler lines need to be replaced, use only double-wrapped and brazed steel tubing. Never use copper or aluminum tubing to replace steel tubing. The steel tubing must be double flared and installed with the correct fittings.

Speedometer Gears and Speed Sensors

The vehicle's speedometer can be purely electronic, which requires no mechanical connection to the transmission, or it can be driven from the output shaft through a cable. Most oil leaks at the speedometer cable can be corrected by replacing the O-ring seal.

Speedometer gear problems normally result in an inoperative speedometer. However, this problem can also be caused by a faulty cable, drive gear, or speedometer. A damaged drive gear can cause the driven gear to fail, and both should be carefully inspected during a transmission rebuild.

On some transmissions, the speedometer drive gear is a set of teeth machined into the output shaft. Inspect this gear. If teeth are slightly rough, they can be cleaned up and smoothed with a file. If the gear is severely damaged, replace the output shaft.

Other transmissions have a drive gear that's splined to the output shaft, held in place by a clip, or driven and retained by a ball that fits into a depression in the shaft. Regardless of the method used to attach the gear, check the retainer and make sure the gear is being held firmly and in the proper position on the output shaft.

The drive gear can be removed and replaced if necessary. The driven gear is normally attached to the transmission end of the speedometer cable. If the drive gear is damaged, chances are the driven gear is also damaged. Most driven gears are made of plastic to reduce speedometer noise; they're weaker than most drive gears. Always check the retainer of the driven gear on the speedometer cable.

Valve Body

One of the most common areas for a transmission problem is the valve body. The valve body controls virtually all transmission functions. Any problem in the many different components that make up the valve body can affect transmission operation and performance.

When trying to find a specific problem in a valve body, it's extremely useful to have a good idea of specifically what you're looking for before removing the valve body. Very often the problems can be too tiny to find through normal examination. Knowing where to look is often the only way of finding the specific failure that's causing the problem.

Once you have a good idea what you're looking for, you'll need to remove the valve body, disassemble it, clean all the components in fresh solvent, and examine them thoroughly. Sometimes simply cleaning and polishing the valves is all that's necessary to take care of a major operating problem. Sticking valves and sluggish valve movement can be caused by poor maintenance, the wrong type of fluid, or overheating.

After all the valves and springs have been removed from the valve body, soak the valve body and separator plates in mineral spirits for a few minutes. Some rebuild shops soak the valve body and its associated parts in carburetor cleaner, and then wash off the parts with water. Thoroughly clean all parts and make sure all passages within the valve body are clear and free of debris. Carefully blow-dry each part with dry compressed air. Never wipe the parts of a valve body with a rag or paper towel: Lint from the rag will collect in the valve body passages and cause shift problems.

Check the separator plate for scratches or other damage. Scratches or score marks can cause oil to bypass oil passages and cause system operating problems. If the plate is defective in any way, replace it.

Check the oil passages in the upper and lower valve bodies for varnish deposits, scratches or other damage that could restrict the movement of the valves. Check all the threaded holes and related bolts and screws for damaged threads, and replace as needed.

Examine each valve for nicks, burrs and scratches. Make sure that each valve fits properly into its respective bore. To do this, hold the valve body vertical and install the unlubricated valve into its bore. Let the valve fall of its own weight into the valve body until the valve stops. Then place your finger over the valve bore and turn the valve body over. The valve should again drop from its own weight. If the valve moves freely under these conditions, it will operate freely with fluid pressure.

If a valve can't move freely within its bore, it may have small burrs or nicks. These flaws can and should be removed. To do this, never use sandpaper or a file; rather, use products such as an Arkansas stone or crocus cloth, which are designed to polish the surface without removing metal from the valve. Sandpaper and emery cloth will remove metal, as well as scratch and leave rough surface. After polishing, the valve must be thoroughly cleaned to remove all polishing residue.

In some rare cases, valves are lapped to a particular valve body. If any parts need to be replaced on one of these valve bodies, the entire valve body must be replaced.

Although it's desirable to have the valves move freely in their bores, excessive wear is also a problem. There should never be more than 0.001" (0.025 mm) clearance between the valve and its bore.

Normally you should replace a valve body with a damaged bore; in some cases there are kits available from the aftermarket to repair damaged bores or valves. Always check your aftermarket parts catalogs for common repair kits: These can not only save you money, but can help you identify common wear areas in the valve body.

Another consideration is checking the valve body for flatness. A maximum of 0.0015" of cup is allowed. If your valve body exceeds 0.0015" cup, you must either machine it flat or replace it.

Always replace the gaskets whenever you remove the valve body. Tightening the valve body bolts crushes the gaskets, so they won't seal a second time. Make sure you're using the right gasket for the valve body and separator plate: Many transmissions today have a number of different gaskets available; using the wrong ones can cause all sorts of problems.

In most cases you'll want to replace any checkballs in the valve body.

Make sure you have them in the proper locations; a misplaced checkball can easily destroy the transmission during a simple upshift.

Make sure you follow the factory torque sequence and specification when tightening the valve body bolts. Doing so will help eliminate leaks and damage to the valve body.

Before beginning to reassemble a valve body, make sure you have the correct gasket by laying it over the separator plate and holding it up to a light. No oil holes should be blocked.

In addition to checking the gasket against the separator plate for blocked passages, you should also check it against the valve body and case channels. Some gaskets may appear correct when checking them against the plate but allow for crossleaks by having gasket slots that cross of channel walls. Keep in mind that it isn't uncommon the have a gasket slot cross over a channel wall, but in those cases the slot will always be perpendicular to the channel wall.

Install all the valve body bolts to hold the valve body sections together and the valve body to the case. Tighten the bolts to factory specifications to prevent warping the valve body and causing possible leaks. Overtorquing can also cause the bores to distort, causing the valves to bind.

Mounts and Torque Struts

The engine and transmission mounts on front-wheel drive (FWD) cars are important to the operation of the transaxle. Any engine movement may affect the length of the shift and throttle cables and can alter gear engagement. Delayed or missed shifts may be the result of linkage changes as the engine pivots on its mounts.

Problems with transmission mounts may also affect the operation of a rear-wheel drive (RWD) vehicle, but this type of problem will be less noticeable than the same type of problem on a FWD vehicle.

Many shifting and vibration problems can be caused by worn, loose or broken engine and transmission mounts. Visually inspect the mounts for looseness and cracks. To get a better look at the condition of the mounts, push up and down on the on the transaxle case while watching the mount. If the mount's rubber separates from the metal plate or if the case moves up but not down, replace the mount.

If there's movement between the metal plate and its attaching point on the frame, tighten the attaching bolts to the appropriate torque. Then, from the driver's seat, apply the foot brake and start the engine. Put the transmission into a gear and gradually increase the engine speed to about 1500-2000 RPM. Watch the torque reaction of the engine on its mounts. If the engine moves too much under load, look for broken or worn drive train mounts.

If the mounts need replacement, follow the manufacturer's recommendations for maintaining driveline alignment. Failure to do this may result in poor shifts, vibrations or broken cables. Some manufacturers recommend a holding fixture or special bolt be used to keep the unit aligned properly.

Be careful choosing the replacement mount. Some mounts are considerably firmer than the original ones: While these mounts will hold the engine in place, they'll also transfer more engine and road noise and vibration to the passenger compartment. These mounts won't cause a safety problem, but they may create a customer complaint.

When removing the transaxle mount, begin by disconnecting the battery's negative cable. Disconnect any electrical connectors that may be located around the mount. It may be necessary to move some accessories, such as the horn, to replace the mount. Label any wires you disconnect to make sure you get them back where they belong.

Install the engine support fixture and attach it to an engine hoist or crane. Lift the engine just enough to take the pressure off of the mounts. Remove the bolts attaching the transaxle mount to the frame and the mounting bracket, and then remove the mount.

To install the new mount, position the transaxle mount in its correct location on the frame. Check the alignment of the mount and lower the engine back onto the mount. Then tighten the bolts to their specified torque. Remove the engine hoist fixture from the engine and reinstall all accessories and wires removed earlier.

Notes:

R&R Procedures

Transmissions come in many different styles and configurations. The specific R&R procedure you follow will vary, depending on the manufacturer, the transmission, and how the vehicle is equipped.

Many of the procedures explained here are generic in nature, and will be pretty much the same no matter what type of car or truck you're working on. In other cases, there will be specific differences for each vehicle. Always consult your shop manual or service program for specific procedures that apply to the vehicle you're working on.

Transmission Removal

Removing the transmission from the RWD vehicle is generally more straightforward than removing one from a FWD model, as there's typically one crossmember, one driveshaft, and easy access to cables, wiring, cooler lines and bellhousing bolts. Transmissions in FWD cars, because of their limited space, can be more difficult to remove, as you may need to disassemble or remove large assemblies such as the engine cradle, suspension components, brake components, splash shields, or other pieces that wouldn't usually affect RWD transmissions.

On RWD vehicles, raise the vehicle and drain the transmission fluid. Mark the driveshaft at the rear axle before disconnecting it to avoid runout-related vibrations. Remove the driveshaft.

On FWD vehicles:

1. Attach a support fixture to the engine.
2. Raise the vehicle.
3. Drain the fluid.
4. Remove the front wheels.
5. Check your shop manual for the procedure to remove the front axles.
6. Disconnect manual linkages, vacuum hoses, electrical connections, speedometer drives, and control cables.
7. Remove the inspection cover between the transmission and the engine.
8. Mark the position of the converter to the flexplate to help maintain balance or prevent runout problems.
9. Rotate the crankshaft to remove the converter bolts. This can be done by using a long ratchet and socket on the crankshaft bolt, or by using a flywheel turning tool.
10. Position a transmission jack before removing any crossmember or bellhousing bolts. The transmission jack allows for easier access to parts hidden by crossmembers or in the space between the trans-

mission and the vehicle floor pan.

11. With a transmission jack supporting the transmission, remove the crossmember or transmission mounts.
12. Remove the starter and bellhousing bolts.
13. Pull the transmission away from the engine. It may be necessary to use a pry bar between the transmission and engine block to separate the two units.
14. Make sure the converter comes out with the transmission. This prevents bending the input shaft, damaging the oil pump, or distorting the drive hub.
15. After separating the transmission from the engine, keep the torque converter in the bellhousing. This can be done simply by bolting a small combination wrench to a bellhousing bolt hole, across the outer edge of the converter.
16. Be sure to check all bellhousing bolt holes and dowel pins. Cracks around the bolt holes indicate the case bolts were tightened with the case out of alignment with the engine block. Replace the case for any of these conditions:
    - broken worm tracks
    - cracked case at the oil pump-to-case flange
    - cracked case at the clutch housing pressure cavity
    - ears broken off the case

Avoid trying to repair the case; there's no way to be sure the repair will hold, because the case is very thin and welding may distort it.

If any of the bolts removed during disassembly have aluminum on the threads, the thread bore is damaged and should be repaired. Thread repair entails retapping the bore or installing a thread insert, which serves as new threads for the bolt. After the threads have been repaired, make sure you clean the case thoroughly.

Exhaust Regulations

On many vehicles, it's necessary to remove part of the exhaust system to get the transmission out of the vehicle. This is important because the laws are very specific regarding vehicle exhaust systems.

That's because the exhaust system is part of the emission control system. And quite simply, if you were the last one to touch it, you're responsible for it.

So, before you remove the first bolt from the exhaust, it's important that you examine it to make sure everything's there, and it's in good shape.

A common situation arises when the customer has removed the catalytic converter. Now you remove the exhaust to install the transmission. Suddenly you're responsible for the catalytic converter being missing. It doesn't matter whether the customer "accepts responsibility for it"; you touched it, so you're responsible… at least as far as the EPA is concerned.

So the customer tells you the catalytic converter is in the trunk. No good: That's now a used catalytic converter. The law specifies that you can't install a used cat unless it's been tested and certified.

At this point you only have one choice: You have to replace the catalytic converter with a new or remanufactured one. And you'll have to provide the customer with the required written notification explaining why the converter had to be replaced (this is usually included in the box with the catalytic converter). Finally, you'll have to keep the old cat around for 15 days, in case the EPA wants to send someone out to evaluate it.

What about rusted or damaged air tubes to the cat? Same deal: Once you touch them, you have to put them back into working condition.

So before you remove the exhaust, make sure you aren't taking responsibility for someone else's problem: Check the exhaust, and make sure that when you put it back, it'll be in factory operating configuration.

Related Components; Axles

The majority of cars on the road today are front wheel drive. This configuration requires a special type of axle to drive the front wheels. The axle must be able to flex with the suspension and turn with the steering, all while continuing to transmit power to the wheels.

The device used for this is the constant velocity joint, or CV-joint. Each axle uses two CV-joints: an inboard one that rides right near the transaxle, and an outboard one that mounts to the steering knuckle.

The reason for the difference is steering: The outboard CV-joint needs to be able to flex horizontally, to compensate for changes in steering. The inboard joint only needs to flex up and down.

Most front axles are held into the transaxle with a snap ring. The splines on the inboard CV-joint mate with the splines on the differential side gears, and the snap ring locks the joint in place. Most manufacturers recommend replacing the snap ring every time you remove the axle from the transaxle.

There's an output seal that seals the transaxle to the outboard CV-joint. And there's a bearing or bushing surface inside the transaxle that holds the CV-joint straight against the seal. If the bushing wears, the seal won't seal properly. In some cases, the correction requires an aftermarket kit, designed to support the CV-joint.

The outboard CV-joint slips through a bearing in the steering knuckle, and through the splines in the front wheel hub. It's held in place with a large nut that's usually locked to a specific torque value.

The only thing you'll be able to check reliably on the outboard CV-joint is the boot that seals it. If the boot is torn, you'll either need to replace the axle, or wash out the CV-joint, repack it with clean grease, and replace the boot.

The only way to check the condition of the CV-joint bearings — short of a complete disassembly and inspection — is by listening for a noise. A worn CV-joint will create a crackling or groaning noise on a hard turn.

Don't confuse that with a whirring noise while driving straight or while turning the wheel slightly; that's more likely the wheel bearing that holds the CV-joint to the steering knuckle.

While some shops may still repair or replace the CV-joints, today it's usually cheaper and easier simply to replace the axle with a rebuilt one.

Related Components; Driveshafts and U-Joints

Most rear-wheel drive vehicles require a driveshaft to transmit torque from the transmission output shaft to the differential. This is a straight shaft with at least two flexing joints — called universal joints, or u-joints — that allow the driveshaft angles to change as the suspension flexes to meet changes in the roadway.

Always check the driveshaft and u-joints when the driveshaft is out of the vehicle. Look for signs of dents, bends or cracks along the entire driveshaft. And look for any indication of a balance weight having fallen off; this can cause a vibration at high speeds.

Check the yokes for wear or damage, and replace them as necessary. You may be able to repair a slight wear along the seal surface by polishing the yoke. Check the splines inside the yoke for wear or damage; make sure it slides freely over the splines on the output shaft, without noticeable wear or binding.

Check the u-joints; they should flex freely, without any wear or looseness. Look for signs of rust along the caps: This indicates the bearings are chewed up and the joint will need to be replaced.

Grab onto the u-joint, and flex it back and forth while applying twisting pressure to the joint. Any roughness or grinding indicates the u-joint needs replacement.

If the vehicle has a double shaft, make sure the u-joints are in alignment between the shafts. If they're out of line, they can cause a vibration under load.

While not a common problem, the angle between the transmission and driveshaft should be equal to the angle between the differential and the driveshaft. A variation in these angles can cause a vibration under load. If you have a vibration and everything else appears okay, check the driveline angles.

Related Components; Freeze Plugs

While the transmission is out of the car, you have a unique opportunity to sell additional repairs. This is because certain components are only accessible when the transmission is out. Freeze plugs are a good example of this.

Freeze plugs are usually metal cups that seal the engine cooling jacket. They're designed to pop out of the block if the coolant freezes, protecting the block from cracking.

But freeze plugs often rust, and that eventually creates a leak in the cooling system. It's easy to identify a leaking freeze plug; the coolant leaves a rusty path that begins at the leak.

Most engines have two freeze plugs between the engine and transmission. The best time to replace them is while the transmission is out of the vehicle. So it's a valuable service to the customer to check the rear engine freeze plugs whenever you have the transmission out of the car.

To replace the freeze plugs:

- Drain the cooling system as completely as possible. After draining the radiator, there are usually one or two plugs threaded into the block that you can remove to drain the block the rest of the way.
- Use a punch or chisel to knock the freeze plug out. Be very careful not to scratch or damage the block itself, or the new plug won't seal.
- Use a flexible brush or scraper to clean any rust or sludge from the block that you can reach from the freeze plug opening.
- Clean the freeze plug opening, and make sure there are no gouges or nicks in the surface.

Now you're ready to install the new freeze plug. The specific procedure depends on the type of freeze plug you're using. New freeze plugs are available in three main styles:

1. Cup plug
2. Rubber expansion plug
3. Metal expansion plug

If you're using a expansion type plug, slip the plug into the hole and tighten the expansion nut. The plug will expand and fill the opening. Don't overtighten the plug; just tighten it enough to make it seal firmly against the block.

If you're using a cup plug, coat the plug with a gasket sealer across the entire inside and mounting surface of the plug. This will help seal the plug to the block, and prevent the new plug from rusting.

Use a driver and a hammer to drive the new plug into the block. Make sure you drive the plug in straight, and don't drive it in too far; just enough for the outside edge to sit flush with the block.

Once you have the new plugs in the block, close the drains and refill the engine. If the coolant looks at all dirty, this might also be a great time to sell the customer on replacing the coolant.

Don't forget to run the engine until the thermostat opens, to make sure the cooling system is full and there isn't any air trapped in the block.

Related Components; Rear Main Seals

The engine's rear main seal seals the back of the crankshaft; if it's worn out, engine oil will leak while the engine's running. And it can be a really bad leak: the kind that just pours out of the engine.

Is it easier to replace the rear main seal while the transmission is out? Sometimes. It depends mostly on the type of seal. Some engines have a two-piece seal that has to be fed through a channel in the block; replacing them requires pulling the engine pan and unbolting the rear main crankshaft bearing cap. Those seals are usually no easier to replace while the transmission is out.

But many engines have a seal that drives into the back of the engine, much like the external seals on the transmission. For those seals, replacing the rear main seal *requires* removing the transmission, so there's no better time to replace them than while the transmission's already out.

The specific removal procedure may vary, depending on the actual seal configuration. In some cases, all you have to do is unbolt a retainer, and the seal slides right out. In others, you may have to use a chisel to collapse the seal.

Installing the new seal again will depend on the type of seal. If it has to be driven in, always use a seal installer to make sure the seal goes in cleanly, without being dented or damaged.

Related Components; Flex Plates and Flywheels

While the transmission's out and on the bench, you should always examine the flywheel or flex plate. Replacing it now is just a matter of a few bolts.

Check the web and mounting surface for damage or cracks. And check the gear teeth for wear or damage. If you see any signs of damage, replace the flywheel.

When replacing the flywheel or flex plate, it's important to compare the old and new components carefully. Here are a few areas to check:

- Overall size — Some flywheels can be just a bit smaller or larger than the original. It's an easy difference to miss, but one that can affect its operation later.
- Gear offset — The ring gear will usually be offset slightly either forward or backward from the mounting surface. Make sure the two gears are offset the same direction and amount, or the starter might not engage with the gear when you try to start the engine.
- Balance weights — Some flywheels or flex plates have additional weights to balance the engine. Make sure you use the same type of flywheel, with the same weights, or you could end up with a vibration in the engine.
- Bolt pattern — Check the bolt pattern against the crankshaft and the torque converter, to make sure it's correct. And if the torque converter has a drain plug, make sure the flex plate has an opening for it to fit through.

Always install all the flywheel mounting bolts, and make sure the flywheel sits all the way down onto the crankshaft before tightening the bolts. And always torque the flywheel bolts to the recommended spec.

Related Components; Dowel Pins

Few components are more overlooked than the dowel pins that align the engine and transmission. A missing or worn dowel pin can cause an engine vibration, repeated cracked flywheels, or damage the front transmission seal or rear main engine seal.

Always check the dowel pins. If they're damaged, worn or missing, replace them. Never attempt to install the transmission without the proper dowel pins: you're just going to create a problem for yourself.

In most cases, you'll be able to remove the old dowel pin with a vise grip pliers and a little wiggle. If you can get behind the dowel pin, you'll be able to drive it out with a hammer and punch.

To install the new pin, simply slide it into place, and seat it with a few light taps with a brass hammer.

Related Components; Mounts and Struts

The engine and transmission mounts and struts are designed to keep the engine and transmission in place, while isolating the vibrations from the passenger compartment. To do this, the mounts and struts are usually made of rubber, or in some cases use an oil to damp vibrations.

Always check the mounts before removing the transmission. If the mounts are torn, the engine could fall out or hang on the hoses or wiring when you remove the trans.

Once you have the transmission out, always check all of the mounts for being broken, crushed or excessively mushy. If you find a problem, replace the mount.

Be careful replacing the mounts. Some engine mounts are oil filled, which allows them to absorb vibrations more efficiently. Some after-market replacement mounts are solid rubber. They're a lot cheaper than the factory mounts, and they'll work fine to hold the engine in place, but can transmit more vibrations than the factory mounts. Always let the customer know about the difference before you install a different style mount.

The torque strut is designed to keep the engine from rocking too far when you accelerate or decelerate. Most factory struts are solid metal, with a rubber bushing on either end. If the bushing wears, the engine will rock back and forth as you give it gas.

A number of aftermarket manufacturers offer a hydraulic replacement strut. These struts provide additional vibration dampening, and are often cheaper than the factory strut. They're a terrific addition, and can even be offered as a benefit to the customer.

Disassembly and Inspection

When cleaning automatic transmission parts, avoid using solvents, degreasers or detergents that can damage the friction plates and bands. Use compressed air to dry components; never wipe parts with a rag. The lint from a rag can easily destroy a transmission after the rebuild.

There are many different ways to clean automatic transmission parts. Some rebuilding shops use a parts washing machine, which takes a little time to clean the transmission case and associated parts thoroughly. These parts washers use hot water and a special detergent that sprays onto the parts as they rotate inside the cleaner.

Many rebuilders simply clean the parts in a mineral spirits tank, where the parts are brushed and hand cleaned. No matter what type of cleaning procedure you follow, always rinse the transmission and parts with water and air-dry them before reassembly.

After the case is clean, remove the torque converter and carefully inspect it for damage. To remove the converter, slowly rotate it as you pull it from the transmission; have a drain pan handy to catch the fluid. It should come out without binding.

This is a good time to check the input shaft splines, stator support splines, and the converter pump drive hub for any wear or damage. Check the converter hub for grooves caused by hardened seals. Also check the bushing contact area. Converters with direct driveshafts should be checked for excessive play at the drive splines of the shaft or converter. If you discover excessive wear or play, replace the converter or shaft as necessary.

Position the transmission to perform an endplay check. The transmission endplay checks can provide information about the condition of internal bearings and seals, as well as clues to possible problems found during the road test. These measurements will also help you determine the correct thickness of the thrust washers during reassembly. The thrust washers' thickness sets the endplay of various components. Excessive endplay allows clutch drums to move back and forth too far, causing the transmission components and case to wear. Always set the endplay to the low end of its specifications.

Perform air pressure tests during disassembly to identify leaking seals, and during reassembly to check the operation of the clutches and servos. During an air pressure test you should be able to hear the clutches and servos apply clearly.

If you hear a hissing noise during an air pressure test, a seal is probably leaking in that circuit. If you can't hear the clutch or servo apply, or if it doesn't react immediately to the air pressure, something is making it stick. Repair or replace the apply devices if they don't operate normally.

You should be able to air test virtually every clutch and servo circuit in the transmission. Some transmissions require you to bolt a specially drilled plate to the transmission case to perform an air test. This plate clearly identifies which passages to test, and seals off the other passages, allowing you to apply air pressure directly through the holes on the plate.

Internal Components and Systems

Pumps

Inspect the pump bore for scoring on its bottom and sides. If the converter fits tightly in the pilot hub, it could hold the converter drive hub and inner gear too far into the pump, scoring the cover. If the front pump bushing has too much clearance, it may allow the gears to run off-center, causing them to wear into the crescent or the sides of the pump body.

Check the stator support shaft for looseness in the pump cover, and for interference inside the torque converter. Examine the shaft's splines and bushing. If the splines are distorted, replace the shaft and pump cover. The bushings control oil flow through the converter and cooler; check their fit carefully. The bushings must fit tight in the stator shaft, with some clearance for the input shaft.

Inspect the gears and pump parts for deep nicks, burrs or scratches. Examine the pump housing for abnormal wear patterns. How the gears fit in the pump body and the centering effect of the front bushing determines the amount of oil pressure loss. Scoring or body wear will greatly increase this pressure loss.

A commonly missed area is pump gear side clearance. Pump gears may have excessive clearance without visible signs of wear. To measure this:

- With the gears or rotor and pump body dry, place them in the pump pocket.
- Place a straightedge across the face of the pump.
- Use a feeler gauge to measure the clearance between the pump gear and straightedge.
- Proper clearance is 0.0015" – 0.002" for pumps that are driven by the converter hub.

Excessive pump clearance is a common cause for a transmission that kills the engine in reverse.

For non-lockup applications, or pumps that are driven by something other than the converter hub (such as a pump driveshaft), clearances aren't as critical, so the clearance doesn't have to be as tight.

Another consideration is pump gear support on the converter hub. The converter hub supports the inner pump gear and keeps it centered. If the converter hub is worn or undersized, or the inside of the pump gear is worn, the inner pump gear will operate off center, due the difference in pressure on the two sides of the gear (high pressure on one side, suction on the other). This can create pump noise. Generally, this noise will get worse as the demand for pressure increases.

To check for a worn hub, place the inner pump gear on the converter hub. If the pump gear is used, be careful not to slide the gear too far down on the hub; you want to check it where it rides during normal operation. The gear should be snug (not tight) on the hub and not wobble.

If the gear wobbles on the hub, replace the gear, converter, or both. If you replace the gear, make sure you replace the inner and out gears as a set. High line pressure is a common cause for excessively worn inner pump gears and hubs. If you find this condition, make sure you check line pressure before delivering the car.

On positive displacement pumps, use a feeler gauge to measure the clearance between the outer gear and the pump housing. Check the clearance between the gears' teeth and the crescent. Compare these measurements to specifications. Use a straightedge and feeler gauge to check the gear side clearance and compare the clearance to specifications. If any clearance is excessive, replace the necessary components.

Variable displacement (vane-type) pumps require different measuring procedures. But check the inner pump rotor-to-converter drive hub fit the same way as described for other pumps. The pump rotor, vanes and slides are originally selected for size during assembly at the factory. Changing any of these parts during a rebuild can destroy this sizing and possibly the body of the pump. You must maintain the original sizing if any parts need replacement. This is why these parts are available in selective sizes.

The vanes are subject to wear, cracks and subsequent breaks. The outer edge of the vanes should be rounded, with no flattening. These pumps have an aluminum body and cover halves; replace them if there's any sign of scoring.

Inspect the reaction shaft's sealing rings. If the rings are made of cast iron, make sure the rings rotate freely in their grooves. Check the clearance between the reaction shaft support ring groove and the sealing ring. If the sealing rings are the Teflon full circle type, cut them out and use the special tools to replace them.

The outer area of most pumps has a rubber seal. Check the fit of the new seal by making sure the seal sticks out a bit from the groove in the pump. If it doesn't, it'll leak. Always replace the seal at the front of the pump during a rebuild. Most of these are metal clad lip seals. Be careful not to damage to the sealing area when removing the old seal.

Check the area behind the seal to be sure the drainback hole is open to the sump. If this hole is clogged, the new seal could blow out. The drainback hole relieves pressure behind the seal. A loose-fitting converter drive hub bushing can also cause the front pump seal to blow out.

Some transmissions are known for front seal pop-out problems. When working on one of those units, always follow the recommendations for preventing this problem. These recommendations will usually include drilling out the drainback hole, installing a special bushing, and using a seal retainer.

Clutches and Bands

Some technicians like to disassemble and examine one clutch drum at a time; others prefer to disassemble all of the drums and inspect them all at once. If you choose the latter, make sure you keep the parts for each clutch separate from the others, so you can be sure which clutch you're looking at, and don't make any mistakes during reassembly.

Clean the clutch assembly components. Make sure you clean off all varnish, burned disc facing material, and steel filings. Take special care to wash out any foreign material from inside the drums and hub disc splines. If left in, that material can be washed out by the fresh transmission fluid and sent through the transmission, ruining your rebuild.

Splines

The clutch splines must be in good shape, with no rounded corners or wear. Test them by fitting new clutch discs on the splines. Move the discs up and down the length of the splines to check for binding. If they bind, it can cause the clutch to drag: Replace the hub and recheck.

Springs

Check the spring retainer; it should be flat, with no sign of distortion at its inner edge. Check all springs for correct height and being straight; look for any cracks; replace any springs that are out of standard or cracked. Many retainers have the springs permanently crimped on. This speeds up production on the assembly line. To check these springs, turn the retainer upside-down, and compare spring length.

Closely examine Belleville springs for signs of overheating or cracking; replace any that appear damaged.

Steel Plates

Make sure the steel plates are flat and not worn too thin. Check all steel plates against the thickest one in the pack or a new one. Check for flatness by placing one plate on top of another and checking the inside and outside diameters. Check for burning or scoring, and for damaged drive lugs. If the plates pass inspection, it's okay to reuse them.

Check the grooves inside the clutch drum and check the fit of the steel plates, which should travel freely in the grooves.

Wave plates are used in some clutch assemblies to cushion the clutch apply. Inspect these plates for cracks and other damage. Never mix wave plates from one clutch assembly with another. As an aid in assembly, most wave plates will have different identifying marks.

Clutch Plates

You're going to replace the friction clutch plates during every rebuild; but you should examine the old plates to help diagnose or identify problems that could cause premature failure in your rebuild.

Clutch facings should be free of chunking, flaking, and burnt or blackened surfaces. Discs that are stripped of their facing have been overheated and subject to abuse.

The facing may come off the disc when the bonding loosens because of extreme heat. As the facing comes off, metal-to-metal contact is made and the disc and plate fuse together. This may lock the clutch on. Depending on which clutch is affected, operating problems can include driving in neutral, binding in reverse, starting in direct drive, binding in second, and other, less common problems.

One possible source of clutch failure is inadequate capacity for the vehicle. Many clutch drums are available in multiple capacities, with different numbers of clutches. In general, the more clutches in the drum, the higher its capacity.

If one or more clutches have failed, make sure that the drum provides adequate capacity for the vehicle before reinstalling it.

Examine the teeth on the inside of each friction disc for wear or damage; look for wear or damage on the mating components, and replace those components as necessary.

Drums and Apply Pistons

Examine the clutch drums and pistons carefully; look for signs of cracks, wear or damage. Pay particular attention to any welds or press fit areas.

Check all sealing surfaces. They should be smooth and even, without any sign of wear or damage. As a rule, if you can feel the wear, there's too much there.

Clean and check any vent capsules or checkballs in the drum or apply piston. Clean them out carefully, and make sure they vent and seal properly.

Examine the ring and seal grooves for wear or cracks.

If the drum has a band apply surface, check that surface carefully. Use a straightedge to make sure the drum's outer edge is flat and provides a clean area for the band to grab. If the outside of the drum is warped or damaged, replace the drum.

Clutch Assembly

If everything looks okay, install new seals. Lubricate them properly, and reassemble the drum. Follow all assembly procedures to make sure you get the drum together correctly. In some cases you may need special assembly tools to install the clutch pistons or sealing rings.

Use the necessary compressors to compress the return spring and install the retaining snap ring.

Once you have the piston and drum assembled properly, stack the clutch pack into the drum.

Clutch Pack Clearance

Proper clutch pack clearance is critical for correct transmission operation. Excessive clearance can cause delayed gear engagements; too little clearance may cause the clutch to drag.

The exact procedure for measuring clutch pack clearance will vary, depending on the transmission you're working on. In some cases you'll be able to adjust the clearance with the large outer snap ring in place. On those units, use a feeler gauge to check the distance between the pressure plate and the outer snap ring, or between the backing plate and the top friction disc.

You also may be able to set clutch clearance with a dial indicator. Use a seal pick or apply air pressure to raise the clutch; the dial indicator should provide the total travel or clearance.

There are several methods available for adjusting clutch clearance, depending on the transmission and drum you're working on. In some cases, selective snap rings are available. Install a thicker snap ring to reduce the clearance; a thinner one to increase clearance.

In other cases, the pressure plate is selective. Some transmissions even have selective steel plates. Regardless of the procedure used, the key is to make sure you adjust the clearance to specs, keeping it as low as possible while making sure you always have some free travel.

Bands

Servicing bands and their components includes inspecting the bands and the drums the bands wrap around. Before the introduction of overdrive automatic transmissions, most bands remained released during high gear. But many overdrive automatic transmissions use a band for overdrive, which puts an additional load on the band. That's why it's important to inspect the bands thoroughly.

The bands in a transmission will be either single or double wrap, depending on the application. Either can be the heavy-duty cast-iron type or the normal strap style.

Never twist or flatten out strap or flex bands: This may crack the lining and eventually cause the lining to flake.

Band failure is easy to spot during a rebuild. Look for chipping, cracks, burn marks, glazing, or erratic wear patterns and flaking. If any of these defects appear, replace the band.

Look at the linings of heavy-duty bands to see if the lining is worn evenly. A twisted band will have a tapered wear on the lining. If the friction material is blackened, it indicates the band was overheated. High heat may weaken the bonding of the lining and allow the lining to come loose.

Check the drum surface for discoloration, scoring, glazing or distortion.

The surface of the drum must also be flat. This isn't usually a problem with a cast iron drum, but it can affect the stamped steel drum. It's possible for the outer surface of the drum to dish outward during normal service.

Check the drum for flatness across the outer surface where the band runs. Any dishing will cause the band to distort as it attempts to get a full grip on the drum, weakening the bond between the friction material and the band. This will cause early failure due to flaking of the friction lining. Replace the drum if it's dished. Check your shop manual for maximum allowable tolerances.

Carefully check the band struts, levers and anchors for wear. Replace any worn or damaged parts.

Air Testing

After you've set the clutch pack clearance, perform an air test on each clutch. This will verify that all of the seals and checkballs in the hydraulic components are able to hold and release pressure. During this air check you'll apply regulated air directly to the drum, while sealing off any other apply holes with your fingers. Since there are no moving surfaces such as oil control rings in the circuit that you're checking, you should hear virtually no air leaking from the clutch seals or drum.

You should also air check the clutches and servos during assembly. This is the best way to check the condition of the circuit. The precise procedure for performing this test varies depending on the transmission you're working on.

Servo Assembly

Servos are basically pistons with seals that fit in a bore, and are held in position by springs and retaining snap rings. On some transmissions, servo assemblies are serviceable with the transmission in the vehicle. Others require complete transmission disassembly.

Before disassembling a servo or any other components, carefully inspect the area to identify any leaks. Do this before cleaning the area around the seal. Look at the path of the fluid leak and identify other possible sources. These sources could be worn gaskets, loose bolts, cracked housings, or loose line connections.

Then remove the retainer and pull the assembly from the bore for cleaning. Check the condition of the piston and springs. Always replace the sealing component, whether it's an oil control ring, lip seal, or a molded rubber piston.

Inspect the outside of the seal. If it's wet, determine whether oil is leaking out or if it's merely lubricating film oil. When removing the servo, continue to look for possible leaks. Check both inner and outer parts of the seal for leaks. When removing the seal, inspect the sealing surface, or lips, before washing. Look for unusual wear, warping, cuts and gouges, or particles embedded in the seal.

Clean all components carefully. Check the servo piston for cracks, burrs, scores or wear. Servo pistons may be made of either aluminum or steel, or may be molded rubber which provides its own seal.

Check all pistons carefully for cracks and for their fit on guide pins. Cracked pistons will create a pressure loss and pistons that are loose on the guide pin allow the piston to leak and bind in its bore.

Regardless of the type of piston, the seal groove should be free of nicks or any imperfection that might pinch or bind the seal. Clean up any problems with a small file or scraper. The piston should have a side clearance of 0.003" to 0.005" (0.076 to 0.127 mm).

Accumulators

Begin accumulator disassembly by removing the accumulator plate snap ring or bolts. After removing the accumulator plate, remove the spring and accumulator piston. Always replace the seals whenever you service the accumulator. Lubricate the new accumulator piston ring and carefully install it on the piston. Lubricate the accumulator cylinder walls and install the accumulator piston and spring. Then reinstall the accumulator plate and retaining snap ring.

Many accumulator pistons can be installed upside down. This results in excess free travel of the piston or too much compression of the accumulator spring. Pay attention to the direction of the piston during teardown, because you may not find a good picture to help during installation. Because accumulator movement affects shift feel, correct installation is critical.

It's common for manufacturers to mate servo piston assemblies with accumulators. This takes up less space in the transmission case and, because they have the same basic shape, can reduce some of the machining during manufacturing.

Gear Train

Planetaries

Inspect the planetary gearset carefully to eliminate the possibility of noises in a newly rebuilt unit. Check planetary gear teeth for chips or broken teeth. If the gear is mounted to a splined shaft, check the splines for wear or damage.

The planetary gears used in automatic transmissions are helical gears, like the ones used in most manual transmissions. This type of gear operates quietly, but makes it necessary to check the endplay of individual gears during inspection. The helical cut makes the gears thrust to one side during inspection. This can put a lot of load on the thrust washer and may wear them beyond specification.

Look for obvious problems like blackened gears or pinion shafts. This indicates severe overloading or lube problems, and requires replacing the carrier. Sometimes the pinion gear and shaft assembly can be replaced individually. A light bluish color can be normal, caused by the heat-treating process during manufacturing.

Check the planetary pinion gears for loose bearings. Check each gear individually by rolling it on its shaft to feel for roughness or binding of the needle bearings. Wiggle the gear to be sure it isn't loose on the shaft and to feel for roughness or binding. Looseness will cause the gear to whine when it's loaded. Inspect the gears and teeth for chips or imperfections, as these will also cause whine.

Check the gear teeth around the inside of the front planetary ring gear. Check the fit between the front planetary carrier and the output shaft splines; here's how:

- Remove the snap ring.
- Check the fit between the front planetary ring gear.
- Examine the thrust washer and the outer splines of the front drum for burrs or distortion. The rear clutch friction discs must be able to slide freely on these splines.

With the snap ring removed, remove the front planetary carrier from the ring gear. Check the planetary carrier gears' endplay by placing a feeler gauge between the planetary carrier and the pinions. Compare the endplay to specifications. On some Ravigneaux units, you'll need to check the clearance at both ends of the long pinion gears.

Check the sun gear splines. Inspect the sun gear's inner bushings for looseness on its shaft. Also check the fit of the sun shell to the sun gear. The shell can crack where the gear mates with the shell. Always replace any shell that varies from true round.

Check the sun shell for being bell-mouthed where it's tabbed to the clutch drum. Excess play between the sun shell and the clutch drum allows the sun shell tabs to strike the clutch drum tabs as the transmission shifts from first to second, or when shifted into reverse.

Check the sun shell for the best fit into the clutch drum slots. This involves trial fitting the shell and drum at all possible combinations and marking the point where they fit the tightest. A snug fit here will eliminate bell-mouthing caused by excess play at the tabs. It can also reduce engagement noise in reverse, second and fourth gears.

The gear carrier should have no cracks or damage. Replace any abnormal or worn parts. Check the thrust washer for excessive wear and, if required, correct the input shaft thrust clearance by using a washer with the correct thickness. Determine the correct thickness by measuring endplay. Some shop manuals will give a range for this endplay; if not, consider about 0.007" to 0.025" (0.178 to 0.635 mm) acceptable.

Drive Chains and Sprockets

The drive chains used in some transaxles should be inspected for side play and stretch. These checks are made during disassembly and should be repeated during reassembly. Measure chain deflection between the centers of the two sprockets:

- Push in on one side of the chain until it's tight.
- Mark its position on the housing.
- Push the chain outward on the same side until it's tight.
- Mark its position on the housing.
- Measure the distance between the two marks

The distance between the two marks is the total deflection. If total deflection exceeds specifications, replace the drive chain.

Be sure to check for an identification mark on the chain during disassembly. This can be a paint mark or a dark colored link. The identification mark can indicate either the top or bottom of the chain, so be sure you remember which side is up.

Inspect the sprockets for tooth wear. If the chain was slack, the sprockets may also be worn, just as engine timing gears wear when the timing chain stretches. A slightly polished appearance on the face of the gears is normal.

Check the bearings and bushings on the sprockets for damage. Examine the thrust bearings for any deterioration of the needles and cage. Check the running surface in the sprocket, as the needles may pound into the gear's surface during operation.

Check the bushings for any sign of scoring, flaking or wear. Replace any worn parts.

On some transaxles, you'll need to spread the sprockets slightly to remove and install the chain drive assembly. The key to this is to spread the sprockets just the correct amount; if you spread them too much, they won't be easy to remove or install.

Differentials

Always inspect transaxle final drive units (differentials) carefully. Examine each gear, thrust washer and shaft for signs of damage. If the gears are chipped or broken, replace them. Also inspect the gears for signs of overheating or scoring on the bearing surfaces.

Final drive units may be helical gear or planetary gear units. On helical gears, check for worn or chipped teeth, overloaded tapered roller bearings, and excessive differential side gear and spider gear wear. Excessive play in the differential can cause engagement clunk. Be sure to measure the clearance between the side gears and the differential case, and check the fit of the spider gears on the spider gear shaft. Look for the clearance specs in your shop manual.

The side bearings of some final drive units are preloaded with shims. Select the correct size shim to bring the unit into specifications. Use a torque wrench to measure the rotating torque. Compare your readings to specifications.

If the bearing preload and endplay are within specs and the bearings are in good condition, you can reuse the parts, but always install new seals during assembly. These bearings are similar to RWD rear axle side bearings, so never set the preload to the new bearing specifications. Used bearings should be set back to the teardown preload, or about one-half the preload of a new bearing.

Check planetary-type final drives for the same differential case problems as the helical type. Examine the planetary pinion gears for looseness or roughness on their shafts and measure the endplay. Any problems will normally require replacing the carrier as a unit, since most pinion bearings and shafts aren't sold separately. Look for specifications for these differentials in your shop manual.

All final drive assemblies are available in more than one ratio, so make sure you're using the same gear ratios during assembly. This isn't normally a problem when rebuilding a single unit, but if your shop is rebuilding a lot of transmissions at the same time, it's possible to mix up parts, causing problems after the rebuild.

Case

Always clean the transmission case thoroughly and blow out all passages. After the case has been cleaned, examine all the bushings, fluid passages, bolt threads, clutch plate splines, and the governor bore. Check the passages for restrictions and leaks by applying compressed air to each one. If the air comes out the outer end, there's no restriction. To check for leaks, plug off one end of the passage and apply air to the other. If pressure builds in that passage, there are probably no leaks.

Modern transmission cases are made of aluminum, primarily to save weight. Aluminum is a soft material that can deform, scratch, crack or score much more easily than cast iron. Pay special attention to the clutch, oil pump, servo and accumulator bores. All bores should be smooth to avoid scratching or tearing the seals. The servo piston could also hang up in a bore that's deeply scored. Check the fit of the servo piston in the bore — without the seal, if possible — to be sure it travels freely. There should be no tight spots or binding over the whole range of travel. Any deep scratches or gouges that cause the piston to bind will require case replacement.

Check case-mounted accumulator bores and clutch bores the same as servo bores. Look for any scratches or gouges in the sealing area that would affect the rubber seals. It's possible to damage these areas during disassembly, so be careful with tools used during a rebuild.

The oil pump bore at the front of the case should be free of any scratches that would keep the O-ring from sealing against the outer diameter of the pump.

Check case sealing surfaces for surface roughness, nicks or scratches where the seals ride. Any problems found in servo bores, clutch drum bores, or governor support bores can cause pressure leaks.

Imperfections in steel or cast-iron parts can usually be polished out with a crocus cloth. Be careful not to disturb the original shape of the bore. Never use sandpaper: that will leave too deep a scratch in the surface. Use a crocus cloth inside clutch drums to remove the marks left by the cast-iron sealing rings. This will help the new rings rotate with the drum as designed. As a rule, replace all sealing rings during a rebuild; this gives the desired sealing surface for proper operation.

Passages in the case guide the fluid through the case. Although not common, case porosity between passages can cause crossleaks from one circuit to another. This can cause bindup (two gears at once), or a slow pressure bleed, which can slowly burn out a clutch or band. If you suspect this, try filling the circuit with solvent. If the solvent leaks down, check each part of the circuit to find the leak.

Be sure to check that all necessary checkballs were in position during disassembly. Inspect small screens throughout the unit for foreign material; these screens prevent valve hangup. Most screens can be removed easily. Be careful during cleaning; some solvents will destroy the plastic screens. Low air pressure from behind can be used to blow the screens out of the case.

Bushings are normally in the rear of the case and require the same inspection and replacement techniques as other bushings in the transmission. Always be sure that the oil passages to a pressure-fed bushing or bearing are open and free of dirt and foreign material.

Vents in the pump body or transmission case prevent pressure from building up in the transmission. You can check these vents by blowing low air pressure through them, squirting solvent or brake cleaning spray through them, or by pushing a small diameter wire through the vent passage. A clean, open passage is all you need to verify proper operation.

Parking Pawl

On some vehicles you can inspect and repair the parking pawl while the transmission is still in the vehicle. Examine the engagement lug on the pawl, making sure it isn't rounded off. If the lug is worn, it may allow the pawl to slip out or not fully engage in the parking gear.

Most parking pawls pivot on a pin. In that case, check the pin for excess wear or damage. Check the spring that pulls the pawl away from the parking gear to make sure it'll remain disengaged while the vehicle is driving.

The pushrod or operating shaft must provide the correct amount of travel to engage the pawl to the gear. Make sure that the shaft isn't bent and the pivot holes in the internal shift linkages aren't worn.

Replace any worn or damaged components. Keep in mind that the parking pawl is the only thing holding the vehicle in place in park. If the parking pawl isn't engaging correctly, the vehicle may roll or even drop into reverse when the engine is running, causing an accident or injury. Replace any questionable or damaged parts.

Bushings

Always inspect bushings for pitting and scoring. Always check the bushings' depth and the direction of the oil groove, if so equipped, before you remove them. Many bushings in the planetary gears and output shaft area have oiling holes. Make sure you align these holes correctly during installation or you may block off oil delivery and destroy the gear train.

Replace all bushings where possible. In some cases a bushing may not be available; in that case, check the bushing clearance. If the bushing is worn beyond the recommended clearances, replace the component.

Always check bushing clearance, even if you replace the bushing. This is especially important with pump bushings. Excessive pump bushing clearance is a common cause of front seal blowout. In fact, some applications are so prone to front seal blowout that you should enlarge the converter drainback hole in the pump.

Generally, a bushing will have about 0.001" – 0.002" clearance per inch in diameter. So a 1.50" bushing should have between 0.0015" – 0.003" clearance between it and the hub.

With larger bores you can use a feeler gauge to measure bushing clearance. For smaller bores you'll need an inside caliper or ball gauge.

Another thing to consider is abnormal wear, such as pitting, discoloring, or wear on one side of the bushing. Pitting and discoloration are often signs of a ground problem, usually caused by a broken or missing ground strap. Bushing discoloration can also caused by lack of lube. The most common cause of lube problems is a restricted cooler. Always make sure you do a proper cooler flush prior to installing the transmission.

Wear on one side of the bushing indicates a centering problem. This is most commonly seen with pump bushings. Worn out engine dowel pins or damaged transmission dowel pin bores can misalign the transmission, moving the pump bushing to one side and making contact with the torque converter hub.

Bushings are made of various materials, most commonly bronze or babbit. It's best to replace the bushing with the same type as originally used, although some applications may require a change from bronze to babbit when the hub it rides on is of a different hardness than the original. This occurs sometimes with pump bushings, where the replacement torque converter hub isn't as hard as the original. In these cases you'll want to use a babbit replacement bushing to avoid converter hub wear. Contact your parts supplier for details.

Most bushings are press-fit into a bore. To remove them, drive them out of their bores with a properly sized bushing tool. Some bushings can be removed with a slide hammer fitted with an expanding or threaded fixture that grips the inside of the bushing. Other bushings can be collapsed in their bore, and then removed with a pair of pliers.

You can remove small bore bushings that are difficult to reach with a bushing removal tool by tapping the inside of the bushing. Thread a bolt into the bushing and use a slide hammer to pull the bolt and bushing out of its bore.

The best way to install a new bushing is to press it in with an arbor press; not drive it in with a hammer. This assures that the bushing remains true and flush and reduces the potential for damaging the bushing during installation.

Thrust Washers and Bearings

Thrust washers support components against thrust load and keep parts from rubbing together, to prevent wear on parts such as planetary gearsets. Selective thrust washers come in various thicknesses to take up clearances and adjust shaft endplay.

Inspect flat washers and bearings for scoring, flaking and wear through to the base material. Check flat washers for broken or worn tabs. These tabs are critical for holding the washer in place. On metal thrust washers, the tabs may appear cracked at the bend of the tab. This is normal; a characteristic of the material used to manufacture them.

Plastic thrust washers won't appear worn unless they're damaged. The only way to check for wear on a plastic thrust washer is to compare its thickness with a new part. Replace any damaged or worn thrust washers and bearings.

Use assembly lube to hold thrust washers in place during assembly. This will keep them from falling out while you're assembling the parts.

Examine all bearings for roughness before and after cleaning. Carefully check the inner and outer races, the rollers, needles, or balls for cracks, pitting, etching or signs of overheating. Replace any that appear worn or damaged.

Shafts

Carefully examine the areas on all shafts that ride against bushings, bearings or seals. Inspect the splines for wear, cracks or other damage. A quick way to identify spline wear is to fit the mating splines together and check for movement.

Check shafts for scoring where they ride in bushings. Any scoring on the shaft indicates a lack of lubrication. The affected bushing should appear worn into the backing metal. Because shaft-to-bearing fit is critical for proper oil travel throughout the transmission, always replace worn shafts.

Lubricating oil is carried through most shafts, so it's important to check them for internal debris: A blocked oil delivery hole can starve a bushing, damaging the shaft. It may not be possible to examine the internal oil passage visually, so the only way to make sure the passage is clear is to check it during cleaning. Wash the shaft passage out with solvent and run a piece of small diameter wire through the passage to dislodge stuck particles.

If there's a ball or plug in the end of the shaft, make sure it seals the shaft and is securely in place. A missing ball or plug could allow lube pressure to leak out, and cause burned planetary gears and scored shafts. Inspect any shaft that has an internal bushing as described earlier. Replace all worn or damaged parts as necessary.

Input and output shafts can be solid, drilled or tubular. The solid and drilled shafts are supported by bushings, so the bushing journals of the shaft should be free of wear. Small scratches can be removed with 300-grit emery paper. Grooved or scored shafts require replacement.

The splines shouldn't show any sign of waviness along their length. Check drilled shafts to be sure the drilled portion is free of any foreign material. Wash out the shaft with solvent and run a small diameter wire through to dislodge any particles. Then wash the shaft once more and blow it out with compressed air.

Some shafts may be used to support another shaft, such as when the output shaft uses the rear of the input shaft to center and support it. Always replace the small bushing in the front of the output shaft on these transmissions during rebuild.

Oil Control Rings

At times, leaks may be from sources other than seals. Worn gaskets, loose bolts, cracked housings, or loose line connections can all cause leaks. Inspect the outside of the seal; if it's wet, see whether the oil is running out or if it's merely a lubricating film. Check both the inner and outer parts of the seal for oil.

While removing a seal, inspect the sealing surface, or lips, before cleaning it. Look for signs of unusual wear, warping, cuts and gouges, or particles embedded in the seal. On spring-loaded lip seals, make sure the spring is seated around the lip and the lip wasn't damaged when first installed. If the seal's lip is hard, it was probably caused by heat from either the shaft or the fluid.

If the seal is damaged, check the shafts for roughness at the seal contact area. Look for deep scratches or nicks that could have damaged the seal. Determine whether the shaft splines, keyway or a burred end could have caused a nick or cut in the seal lip during installation.

Inspect the seal housing bore: Look for nicks and gouges that could create a path for oil leaks. A badly machined bore can allow oil to seep out through a spiral path. Sharp corners at the bore edges can score the seal's metal case during installation. These scores can make a path for oil leaks.

Oil control rings are designed to rotate in the channels cut into the shaft, not against the drum surface. If the rings seize in the shaft, they can wear grooves into the drum surface. This is often caused by high line pressure. In addition, excessive geartrain endplay of drum bushing-to-hub clearance can allow the drum to cock on the support and make contact with the ring tower while rotating. This is apparent when there are two grooves in the drum where a single ring should ride.

Since oil control rings rotate with the drum they are sealing, metal rings can sometimes cause wear the ring groove. To check for excessive wear in the sealing ring groove, measure the side clearance with a feeler gauge. Proper side clearance for a metal ring is 0.002" – 0.004".

Teflon sealing rings operate with much higher side clearance, and are less likely to wear into the metal grooves, so this measurement isn't important during rebuild. Never replace a metal ring with a Teflon ring that operates on an aluminum support. The Teflon ring will almost always wear out the support.

Always bore fit new rings before installing. That way you'll know you're using the right ring, and that the ring will seal properly during operation.

Check all check valves and checkball contact surfaces. Make sure they seal properly and operate freely during use. Improper sealing can cause a leak that will damage the transmission or affect its operation. Failure to bleed properly can cause the component to become air bound, and cause transmission operating problems and early failure.

One-Way Clutches

Because they are purely mechanical in nature, one-way clutches are relatively simple to inspect and test. The durability of these clutches relies on constant fluid flow during operation. If a one-way clutch fails, inspect the hydraulic feed circuit to the clutch to see if the failure was caused by fluid starvation. The rollers and sprags ride along a race while overrunning; any loss of fluid can allow them to overheat and fail.

Sprags, by design, produce a wave in the fluid as they slide across the inner and outer races, making them somewhat less prone to damage. Rollers, due to their spinning action, tend to throw off fluid, which makes them more likely to suffer from fluid starvation.

While checking the hydraulic circuit, examine the feed holes in the races of the clutch. Use a small diameter wire and spray carburetor cleaner or brake cleaner to make sure the feed holes are clear. Push the wire through the feed holes and spray the cleaner into them. Then blow them out with compressed air.

Disassemble roller clutches to inspect the individual components. The surface of the rollers should have a smooth finish with no evidence of any flatness. Likewise, the race should be smooth and show no sign of roughness, as this indicates severe impact loading. This condition may also cause the roller clutch to buzz as it overruns.

Check the roller clutch springs for cracks, broken ends, or flattening. All of the springs should be about the same shape and size. Replace the clutch assembly if the springs are distorted. Then check for proper tension: Hold the roller clutch by its cage, and give it a little shake. The springs should hold the rollers in place. If the rollers fall out of the cage, the springs are weak: Replace the roller clutch assembly.

Replace any races or cams that show any damage, wear or surface irregularities.

Sprags can't easily be disassembled, so a complete and thorough inspection is necessary. Pay particular attention to the faces of the sprags. If the faces are damaged, replace the sprag. Scored or torn faces indicate dry running: Replace the complete unit, and make sure the clutch is receiving proper oil.

Check your service bulletins; manufacturers sometimes offer replacement sprags or roller clutches to improve operation and holding characteristics. Always use the latest version one-way clutch, to avoid problems later.

Once the one-way clutch is ready for installation, verify that it overruns in the proper direction. In many cases — particularly with sprags — it's possible to install the clutch backward, which would cause it to overrun and lock in the wrong directions. This would create serious operating problems. Most shop manuals provide a clear picture of the direction for locking and freewheeling; make sure you have the clutch assembled correctly before installing it in the case.

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Assembly and Checks

CAUTION: Never use wheel bearing or axle grease as an assembly lube; these greases contain molybdenum, which can prevent sprags and roller clutches from holding properly.

Before proceeding with the final assembly, make sure the case, housing and parts are clean and free from dust, dirt and foreign matter. Have a tray available with clean ATF for lubricating parts and a jar or tube of assembly lube for securing washers during installation. Coat all parts with the proper type of ATF. Soak bands and clutches in the fluid for at least 15 minutes before installing them. All new seals and rings should have been installed before beginning final assembly.

Carefully examine all thrust washers and coat them with assembly lube before putting them in place.

Assemble the transmission carefully, one component at a time. Make sure you check all components for proper alignment and operation as you install them. Many transmissions have more than one endplay adjustment; always check the endplay adjustments carefully, and adjust them as necessary.

Once you have the components installed in the case, install the pump carefully. Use alignment dowels to make sure you have the pump aligned with the bolt holes. Seat the pump as much as possible before installing the bolts. Then bolt it down evenly, and torque the bolts to factory specs.

Install any checkballs or screens in the case. Check the gaskets against the separator plate to make sure you're using the right ones, then install the valve body onto the case. Use alignment dowels to align the valve body to the worm tracks in the case. Install all the bolts before tightening them.

On some transmissions you'll need to adjust the valve body or manual valve alignment before tightening the valve body bolts. Make sure everything is aligned properly before you tighten the bolts.

Torque Converter

Most torque converters today come with a clutch facing inside them. Since that facing can't be replaced in the shop, you'll need to replace the torque converter with every rebuild. In most cases, you'll use a rebuilt converter. But whether you're using a rebuilt converter or a new one, you'll always want to check it carefully before installing it in your rebuild.

Inspect the converter's drive lugs or studs carefully. These hold the converter to the flexplate to make sure the converter rotates in line and evenly with the flexplate. The threads on the studs or lugs should be clean and in good condition. They should also be tightly seated into the torque converter. Check the shoulder area around the lugs and studs for cracked welds or other damage.

If the internal threads of a drive lug are damaged, you can repair it by tapping the threads or installing a threaded insert. If you find any other damage, replace the converter. Also inspect the converter attaching bolts or nuts, and replace them if necessary.

Check the hub of the torque converter. It should be smooth, with no signs of wear. If the hub is worn, carefully inspect the oil pump drive and replace the torque converter. Light scratches, burrs, nicks or scoring marks on the hub surface can be polished out with a fine crocus cloth. Don't allow dirt to enter the converter while polishing the hub. If the hub has deep scratches or other major imperfections, replace the converter.

In general, replace the torque converter if it has fluid leaking from its seams or welds, loose drive studs, worn drive stud shoulders, stripped drive stud threads, a heavily gouged hub, or excessive runout.

Transaxles that don't have their oil pump driven directly by the torque converter use a driveshaft that fits into a support bushing inside the converter hub. Check this bushing for wear: Measure the inside diameter of the bushing and the outside diameter of the driveshaft; the difference between the two measurements is the amount of clearance. If the clearance is excessive, replace the bushing.

Endplay, Preload and Clearances

While a transmission operates, the gears, shafts and bearings are subject to loads and vibrations. Because of this, the drivetrain must normally be adjusted for the proper fit between parts. These adjustments require the use of precision measuring tools. There are three basic adjustments to consider:

1. Adjusting the clearance or play between two gears in mesh is referred to as adjusting the *backlash*.
2. *Endplay* adjustments limit the amount of end-to-end movement of a shaft.
3. *Preload* is an adjustment made to put a load on an assembly, to offset the load the assembly will face during operation.

Backlash is the clearance between two gears in mesh. Excessive backlash can be caused by worn gear teeth, the improper meshing of teeth, or bearings that don't support the gears properly. Excessive backlash can result in broken gear teeth caused by severe impact from sudden stops or directional changes. Insufficient backlash causes excessive wear on the gear teeth and can cause premature failure.

You'll usually measure backlash with a dial indicator mounted with its stem in line with the rotation of the gear, and perpendicular to the angle of the teeth. Move one gear in each direction while holding the other gear. The amount of movement on the dial indicator equals the amount of backlash present. Adjusting the shims on the gear shaft is the normal procedure for making backlash adjustments.

Endplay refers to the measurable up-and-down looseness of a bearing. Always measure endplay with the gears unloaded. To check endplay, mount a dial indicator against the outer side gear or the end of a shaft. Then pry the gear or shaft in both directions and check the readings. The difference between the two readings is the amount of endplay. Shims or adjusting nuts are used to adjust endplay.

When normal operating loads are high, gear trains are often preloaded to reduce deflection. The amount of preload is specified in service manuals and must be adjusted for the design of the bearings and the strength of the parts. If you preload the bearings too much, they'll heat up and fail. If you set the bearings too loose, the shaft will wear rapidly due to excess deflection. Gear trains are preloaded by shims, thrust washers or adjusting nuts, or by using double race bearings. You'll usually check preload adjustments by measuring turning effort with a torque wrench.

Air Testing

In some cases you'll assemble the drums onto the pump, and apply regulated air through the pump and stator shaft. This will pressurize the clutch apply circuit, and should apply the clutches. A slight air leak around the oil control rings is normal during this type of air check.

In other transmissions you'll air check the clutches through the transmission case. Exactly how you do this depends on the transmission; in some cases you'll be able to access the apply ports directly. In others, you'll need a sealing block or test plate mounted to the case to seal off the worm tracks and provide a clear apply circuit for testing.

Be sure to use low-pressure compressed air to avoid damaging the seals. High-pressure air may blow the rubber seals out of the bore or roll them on the piston.

While applying air pressure, you may notice some air escaping from around the sealing rings. This is normal, as these rings create a controlled leak to provide lubrication. There should be no air escaping from the piston seals. The clutch should apply with a dull but positive thud, and should release quickly without any delay or binding.

Bolt Torque

Check the factory specs for torque and tightening pattern. Make sure you follow these specs precisely: overtightening the valve body bolts, or tightening them in the wrong order, can distort the valve body and cause valves to bind. For best results, always torque the bolts in three steps. Then wait 5 or 10 minutes, and recheck the torque.

Finally, install the pan gasket and pan. Once again, torque the bolts to factory specs.

Road Testing and Delivery

The transmission's rebuilt, it's back in the car, and it goes right into gear. It's ready to deliver, right?

Not so fast! Before you hand the car back to the customer, you need to perform a complete road test and final examination on the car. That should include checking:

- Transmission operation.
- For any vibrations, noises or driveability issues that could affect customer satisfaction.
- Computer system operation, to make sure there are no codes left in memory.
- For any sign of leaks.

So, before you call the customer to "come and get it," get ready to perform a complete road test and diagnostic check… one last time.

Road Testing Procedures

Before you go on any road test, make sure the fluid is full, and check the transmission for any sign of leaks. Finally, connect your scan tool, and check for any codes in memory. If there are any codes, record them and clear them from memory. Hopefully any codes that are there were just set during the installation, before everything was plugged back in; if they return during the road test, you'll know you need to look into them further.

Now go for a drive; a good long one. Make sure you stop and start several times, so you can feel the transmission shift through all the gear ranges. Try it at all throttle openings, including light throttle, normal throttle, and heavy throttle. Make sure it kicks down properly on a hard throttle.

And drive it on all types of roads conditions, including slow, stop-and-go driving and highway cruise.

All the while, look for any shift problems: Soft or skipped shifts, harsh shifts, or anything that could indicate a problem.

Computer Retraining

During your road test, you'll want to perform a basic computer retraining procedure. The specific procedure will vary from vehicle to vehicle, but in general it will include:

- Allowing the transmission to warm up from cold to normal operating temperature.
- Accelerating from a stop to high range, at light, medium and heavy throttle ranges, at least three times for each.

- Driving at cruising speeds with the transmission fully warmed up, for at least 3 minutes.

While this will provide a very basic retraining, it won't complete the transmission adaptation. That'll take a few weeks of normal driving, and will require the owner to drive the vehicle. Make sure the customer understands that the computer will continue to adjust its operation over the next couple weeks.

Final Checks

Once you get back from your road test, put the car back on the lift, and check the transmission for any sign of leaks. Some leaks won't show up until after the car has been driven for a few miles.

While you have it in the air, check the pan gasket bolts, cooler lines, and so on for proper torque. They may have loosened slightly with the drive and temperature changes.

Check the computer system for codes one last time. There shouldn't be any; if there are, start looking for a problem or failure in the computer system. If the code is the same one that was set before your road test, you can bank on it being a hard code: A problem that's there now. A new code may indicate an intermittent problem, such as a loose wire or connection. Check the problem carefully, and make sure it's gone before you deliver the vehicle.

Finally, check the transmission fluid level one last time. Very often air will be trapped inside the clutch drums or passages. Driving the vehicle will bleed the air, and let everything fill up the rest of the way. This may require as much as a quart of fluid to top the unit off.

Once everything's tight, the codes are clear, there are no leaks, and the transmission's operating properly, it's time to deliver the vehicle. Make sure you remind the customer to come back in a couple weeks for a final checkup.

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