The Chain of Command

By Mike Weinberg
Contributing Editor

During the past several decades the transmission-repair industry has been inundated with a huge growth in the numbers of transmissions and transfer cases used in automobiles and light trucks. This has caused a phenomenal growth in the number of parts involved in the repair process and a huge learning curve in respect to repair and diagnostic procedures.

There are many parts that technicians take for granted and replace routinely without understanding the technology and engineering necessary to produce these parts. One of the most-common replacement items used by our industry is the drive chain. Once limited to transfer-case designs, drive chains were a natural way to transfer power between parallel shafts in front-wheel-drive automatic transmissions.

Whereas it once was confined to a few early front-wheel-drive automatics like the TH425 and 325 units, the drive chain is now a huge-volume replacement part, used daily by repair shops worldwide. What is not commonly apparent is the complexity of the design and engineering of the chain and the drive and driven sprockets used to transfer torque. This article is devoted to helping you understand the theory and operation of the drive chain in transmissions and transfer cases.

The foremost manufacturer of drive chains for the automotive industry is the Morse TEC division of BorgWarner. Much of the information provided here is courtesy of Carol Dupke Lee of the Morse TEC division, and she has my thanks for the wealth of knowledge she provided.

There obviously are other manufacturers of drive chains, but the Morse TEC division of BorgWarner is the supplier of choice for most of the automotive industry. In my opinion, there is always someone who will sell you a product for less, but you will not have the same engineering and design capabilities in that product as you will through a company that is the OEM supplier. The testing and research that go into a product in order to be validated for use by the vehicle manufacturers is unbelievably demanding, and I would rather buy the product that they have tested and approved than take a chance on a will-fit product.

The parameters for the design of a chain must take into account many issues that must be addressed to satisfy the customer. Noise and vibration are present in all moving parts of the vehicle, and the chain must be engineered to minimize intrusion of noise and vibration into the passenger compartment. The materials that make up the chain must have sufficient tensile strength to handle the engine torque load and speed range and provide long-term durability for the sprockets and the chain itself. The chain must be able to accept the centrifugal forces generated during operation.

Fatigue strength is the ability of the chain to live with the loads and operating conditions over the life of the vehicle. The chain is wear rated to measure the wear incurred during operation. As you can see, the chain lives in a harsh environment and is subject to driver abuse. Consider the effect of a driver spinning the drive wheels of the vehicle on ice or snow. The engine speed is high if not maxed out, and the transmission/transfer-case components also are moving at warp speed. The tires now contact a dry patch that permits them to regain grip, immediately causing the moving parts to come to a momentary stop under the maximum torque load. The design limits of all the components of the driveline must take into account these conditions and have the strength to absorb punishment in excess of normal operation.

The chain is composed of many parts, and understanding their names and functions is important.

Link apertures is a fancy name for the holes in the chain links. These will be either round or rocker-joint shapes that match the connecting pins. This is the area of articulation or flexible movement of the chain. Round-pin chains are extremely flexible and can be rolled into a ball. Rocker-joint types do not have that much flexibility.

Guide links are the link plates on the outside of the chain that act as guides to keep the chain centered on the sprockets.

Link flank is the lower tooth-like part of the link that meshes with the sprocket teeth.

Link crotch is the valley or space between the links that clear the sprocket-tooth tip.

Link back is the outside curve of the link design to provide

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strength and smoothness of operation. Some link backs are curved, and others are flat.

Round pin is a single round pin that is used to articulate the chain.

Rocker-joint pins are two pins used to articulate the chain. Some styles are triangular, and others are oval shaped.

Chain operational and measurement terms

Pitch – the effective length between the center point of the link apertures (holes), which are the points of chain articulation or flex.

Width – the approximate measurement between the inside and outside guide links, which is close to the width of the sprockets.

Random chain – certain patterns created by interlacing different link styles in a random pattern across the width of the chain. The purpose is to cancel noise and harmonic vibrations generated by the movement of the chain. A new design element in Morse TEC chain construction is the "Gemini" system, which uses two thinner chains running on parallel sprockets instead of one wide chain. The sprocket teeth are staggered so that the two chains are running one tooth off from each other. This process uses the two conflicting sets of chain harmonics to cancel themselves out mechanically, making chain operation as silent as possible.

Chordal action – the radial or transverse motion of the chain resulting from engagement with the sprockets. This engagement creates the chain sound level.

Decibel measurements – the measurement of the total sound coming from the system during operation.

Chain description – the nominal measurements of the chain. Example: $\frac{3}{8}$P X $1\frac{1}{4}$ W X 72P. This translates into $\frac{3}{8}$ pitch by $1\frac{1}{4}$ inch approximate width by 72 total pitches. 72 pitches equals 32 guide plates per side.

Identifying and troubleshooting chain problems

It is important to note that the chain and the sprockets for each application are matched sets. If you are changing sprockets it is important to replace them along with the chain as a matched pair to prevent noise problems.

If you tear the unit down and find any signs of discoloration of

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the lubricant, the chain or the inside of the cases, replace the chain. Chains suffer from elongation or stretch from high mileage, and from overheating due to low lube level or improper lube. The smart move is to sell the customer a chain as part of the repair. A chain failure is always catastrophic, with the case halves being destroyed along with other internal parts.

Measuring chain stretch accurately is virtually impossible for the technician. The error rate in trying to eyeball chain stretch or using a ruler is over 50%. The chains are cheap enough and the comebacks too expensive to take chances.

Excessive chain wear on the guide link inside the flank area is caused by misaligned or out-of-parallel sprockets. This is due to excessive endplay or bearing failures that permit the shafts to run out of alignment. It usually is necessary to replace the sprockets and the chain.

Wear on the outside or back of the chain usually is caused by excessive elongation that usually leads to contact with the internal walls of the case. The chain and sprockets must be replaced as a matched set.

A burnt chain is caused by low lube or an overheating condition and will require chain replacement.

Broken links and/or turned or sheared pins indicate an overload of the system creating excessive chain slack and jumping. This usually occurs in vehicles used for extreme duty such as heavy snow plowing or real off-road work. It occasionally can result from an object getting wedged into the chain after failure of some other parts. Determine with the customer the usage of the vehicle, and show them the damage to prevent the same problem with a repaired unit.

Extreme wear to the tooth flanks comes from worn sprockets and lack of lube. Replace the chain and the sprockets, and correct the lubrication issues.

Premature extreme sprocket wear usually is caused by mismatching a new sprocket with an old one. When replacing sprockets, make sure they are matched pairs for long life and durability.

Burnt or foul-smelling lubricant is a product of overheating or low lubricant level. Replace the chain

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and any other damaged components. In an automatic transmission you probably will find burnt clutches and/or a failed torque converter.

Excessive noise or vibration should require a very careful inspection of the chain for broken links, low lube or misalignment or excess runout of the sprockets. This will require a careful analysis of endplay, runout on the shafts and sprockets, all bearings, and alignment of the case halves.

Milky discoloration of the fluid usually results from water contamination. This is common on vehicles used off road where the driver goes through mud, snow or water deep enough to enter the unit through the breathers. If the owner enjoys real off-road travel, extend the breathers through hoses to a point high enough to avoid water entry, and encourage the owner to drain and replace the fluid after every off-road adventure.

As you can see, the simple-looking chain is a marvel of engineering that has been designed to perform at high speeds under extreme changes of torque load. A lot of work has gone into making the chain as silent as possible, and proper service and lubrication should provide years of good service. Use the best and you won't have to worry about the rest. TD

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As Seen In Transmission TECH/TALK®
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THM 4L60-E

Driveline Vibration

Complaint:

2000-model trucks equipped with 4L60-E transmissions and either 4.8- or 5.3-liter engines may experience a driveline vibration at speeds between 35 and 50 mph during conditions of low engine speed and the driver's foot off the accelerator pedal.

Cause:

The torque-converter clutch being applied during these low-engine-speed conditions (100-1,400 rpm) transfers engine torsional vibration into the drivetrain, resulting in noises and vibration that could be either heard or felt.

Correction:

Verify the vehicle year. On 2000 models, the 10th digit of the VIN is Y. Next, verify the engine size, using the eighth digit of the VIN. V indicates a 4.8-liter with RPO code LR4. T indicates a 5.3-liter with RPO code LM7. These codes are on the left side of the engine block below the cylinder head. Once you have verified this information, you will need to reprogram the vehicle's PCM. Refer to the chart in Figure 1 for the appropriate calibration number.

Special Correction:

On any ECC application requiring the torque converter to contain a woven-carbon clutch, be sure that this style clutch is used. Kevlar, cellulose or any material other than the special carbon clutch by General Motors will not live in this environment and also may cause driveline vibration before failure.

Figure 1 VEHICLE APPLICATION CHART

ENGINE	CALIBRATION #	AXLE	APPLICATION
4.8	9358172	3.42	C100
4.8	9358173	3.73	CK100
4.8	9358174	4.10	K100
5.3	9358175	3.42	C100/200
5.3	9358176	3.73	C100/200 K100
5.3	9358177	4.10	C100/200 K100