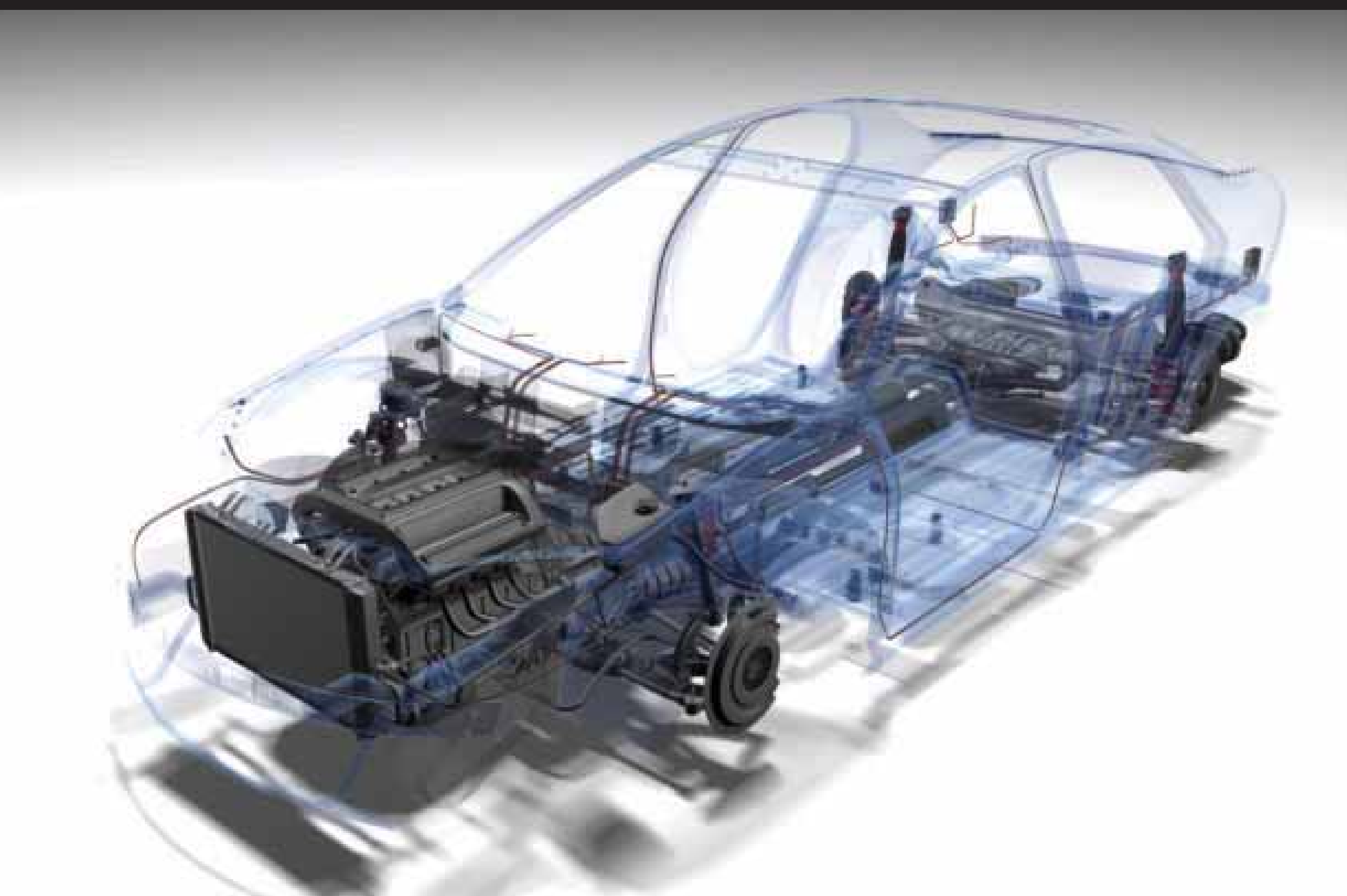
Dealer Training Series

Mobile Drivetrain Fluids

A Technical Introduction to Drivetrain Lubrication | Presented by AMSOIL INC.



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Drivetrain Introduction: Section 1
Mobile Drivetrain Fluids

Introduction

The following course is a technical introduction to the components, operation and lubrication requirements of mobile drivetrain systems. Viscosity requirements for drivetrain lubricants, including industry grading systems, will be covered, in addition to the concept of gear ratios, major drivetrain components, common additives in drivetrain lubricants and the importance of controlled frictional properties for these fluids.

Upon completion of this course you will have a basic understanding of the operation and fluid requirements of mobile drivetrain equipment.

Section Objectives

After studying Section 1, you should understand and be able to explain the following terms and concepts:

1. Components that make up a vehicle's drivetrain
2. The drivetrain's primary function in the vehicle
3. Current changes being made to drivetrain systems and the reasons behind them
4. Conditions that create *severe service* vehicle operating conditions
5. Additive supplements
6. Key tools for selling AMSOIL products and drivetrain fluids

Section Keywords

The following keywords are defined in this section. Pay particular attention to their explanations as these concepts will serve as building blocks for future lessons.

Drivetrain
Torque
Transaxle

Explanation of the Drivetrain

The ***drivetrain*** consists of all the components, located between a vehicle's engine and wheels, that allow a vehicle to move. The drivetrain's job is to generate the necessary thrust and rotational force, referred to as ***torque***, to keep a vehicle moving despite changing operating conditions.

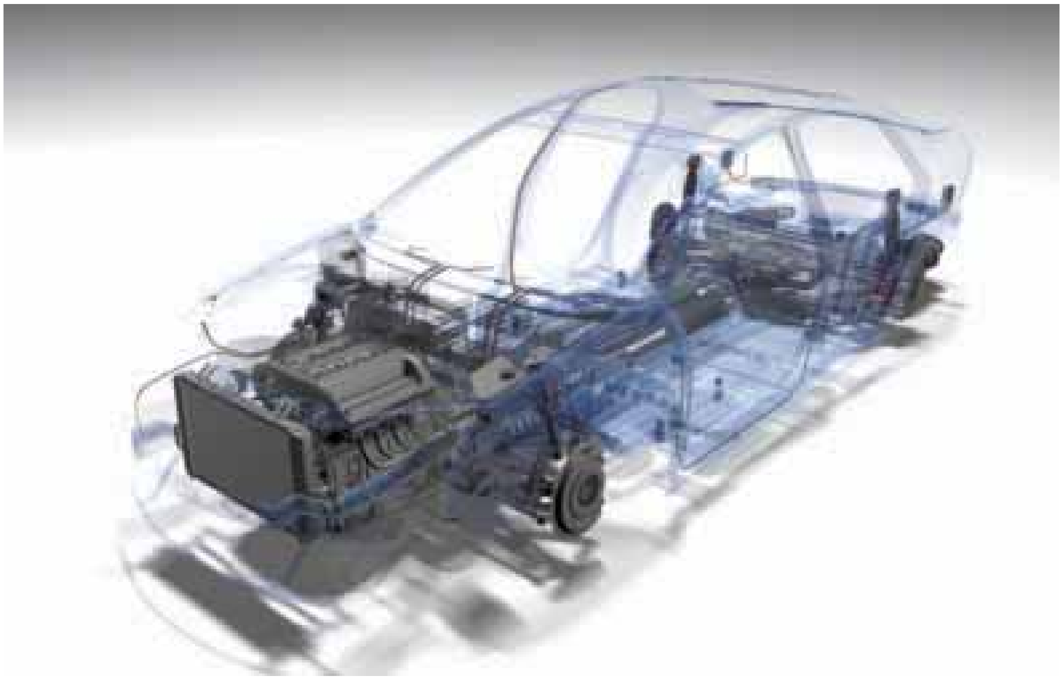

Figure 1.1
The drivetrain is all of the components between the engine and wheels that propel a vehicle in motion.

The transmission uses the rotation of the engine's crankshaft to increase and decrease torque by generating different gear ratios. The transmission makes torque adjustments based on driving conditions such as speed changes, load, inclines and cornering. For example, if loading conditions for the vehicle increase (i.e. traveling uphill), the transmission increases the torque output to prevent the vehicle from slowing down; this is accomplished as the transmission downshifts into a lower, more forceful gear.

Transmissions that are located in close proximity to the driven axle are often combined with the axle components and is collectively referred to as a ***transaxle.*** Transaxles are most common in front-wheel-drive (FWD) vehicles.

The drivetrain system encompasses other components such as the differential, transfer case and power-takeoff unit. Each of these parts fulfills a different function within the drivetrain system. These components will be discussed in greater detail later in the course.

Drivetrain Gear Lubricant Viscosity Grading Systems

Viscosity is the most important property when selecting a gear lubricant. Industry organizations have created different grading systems to simplify lubricant selection for gear oils. The three most common gear lubricant grading systems are developed and maintained by the American Petroleum Institute (API), the Society of Automotive Engineers (SAE) and the U.S. Military.

Drivetrain Gear Lubricant Viscosity Grading Systems

API Automotive Service Classifcations for Gear Oil
(July 1995)

GL-1	• Manual transmission operating under mild conditions where petroleum or refined petroleum oils are suitable • Oxidation and rust inhibitors, defoamants, and pour depressants may be added to improve the lubricant • Friction modifiers and EP additives cannot be used
GL-4	• Intended for axles with spiral bevel gears operating under moderate to severe conditions of speed or load • Axles with hypoid gears operating under moderate speeds and loads • Lubricants are acceptable in selected manual transmissions and transaxle applications where API MT-1 lubricants are unsuitable
GL-5	• Intended for gears, particularly hypoid gears in axles operating under various combinations of high-speed shock loads and low-speed, high-torque conditions • MIL-L-2105D lubricants satisfy this GL-5 specification (API classification does not require military approval)
MT-1	• Intended for non-synchronized manual transmissions used in buses and heavy-duty trucks • API MT-1 lubricants provide protection against the combination of thermal degradation, component wear, and oil seal deterioration that is not provided by lubricants meeting only the requirements of API GL-4 and API GL-5

Figure 1.2
American Petroleum Institute service classifications for gear oil

The API classifies gears using GL ratings, ranging from GL-1 to GL-5 (Figure 1.2). Higher GL rating numbers represent more severe applications; GL-1 is the least severe and can usually be satisfied with a motor oil, while GL-5 is the most severe GL rating. Gear lubes meeting the MT-1 rating must be non-reactive with the copper and copper alloys often used in friction surfaces in manual transmissions. See pages 28 - 29 for more information on manual transmission synchronizer elements.

Gear lubricants are often referred to as grease; however, this is technically incorrect because gear lubricants more closely resemble motor oils than grease. Another common misconception is that gear lubricants are thicker than motor oil, which is usually untrue.

SAE gear lubricant grade numbers are larger than SAE motor oil grades; however, this does not mean they are necessarily thicker than motor oils. Gear lubricant grades are determined on a different grading scale than motor oils. Rather than use the same classification guidelines, two separate grading systems were developed to minimize confusion between SAE gear oil and motor oil grades.

SAE J-306 Automotive Gear Lubricant Viscosity Classification

SAE Viscosity Grade	Maximum Temperature for Viscosity of 150,000 cP (°C)[1,2]	Kinematic Viscosity at 100°C (cSt)[3] Minimum[4]	Kinematic Viscosity at 100°C (cSt)[3] Maximum
70W	-55[5]	4.1	–
75W	-40	4.1	–
80W	-26	7.0	–
85W	-12	11.0	–
80	–	7.0	< 11.0
85	–	11.0	< 13.5
90	–	13.5	< 18.5
110	–	18.5	< 24.0
140	–	24.0	< 32.5
190	–	32.5	< 41.0
250	–	41.0	–

(1) Using ASTM D 2983
(2) Additional low temperature viscosity requirements may be appropriate for fluids intended for use in light duty synchronized transmissions.
(3) Using ASTM D 445
(4) Limit must also be met after testing in CEC L-45-A-99, Method C (20 hours)
(5) The precision of ASTM D 2983 has not been established for determinations made at temperatures below -40°C. This fact should be taken into consideration in any producer-consumer relationship.

Figure 1.3
Society of Automotive Engineers gear lubricant viscosity classification (SAE J-306)
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The SAE J306 classifies gear lubricant viscosity grades (Figure 1.3). See the Viscosity Comparison chart for comparisons of SAE motor oil and gear oil grades (Figure 1.5).

Military MIL-PRF-2105E

US Military Symbol	SAE Viscosity Grade	Kinematic (cSt) at 100°C min	Kinematic (cSt) at 100°C max	Brookfield Viscosity Max temp for 150,000 cP
GO-75	75W	4.1	–	-40
GO-80/90	80W-90	7.0	> 24	-26
GO-85-140	85W-140	11.0	> 41	-12

Figure 1.4
The military drivetrain gear lubricants grading system (MIL-PRF-2105E)

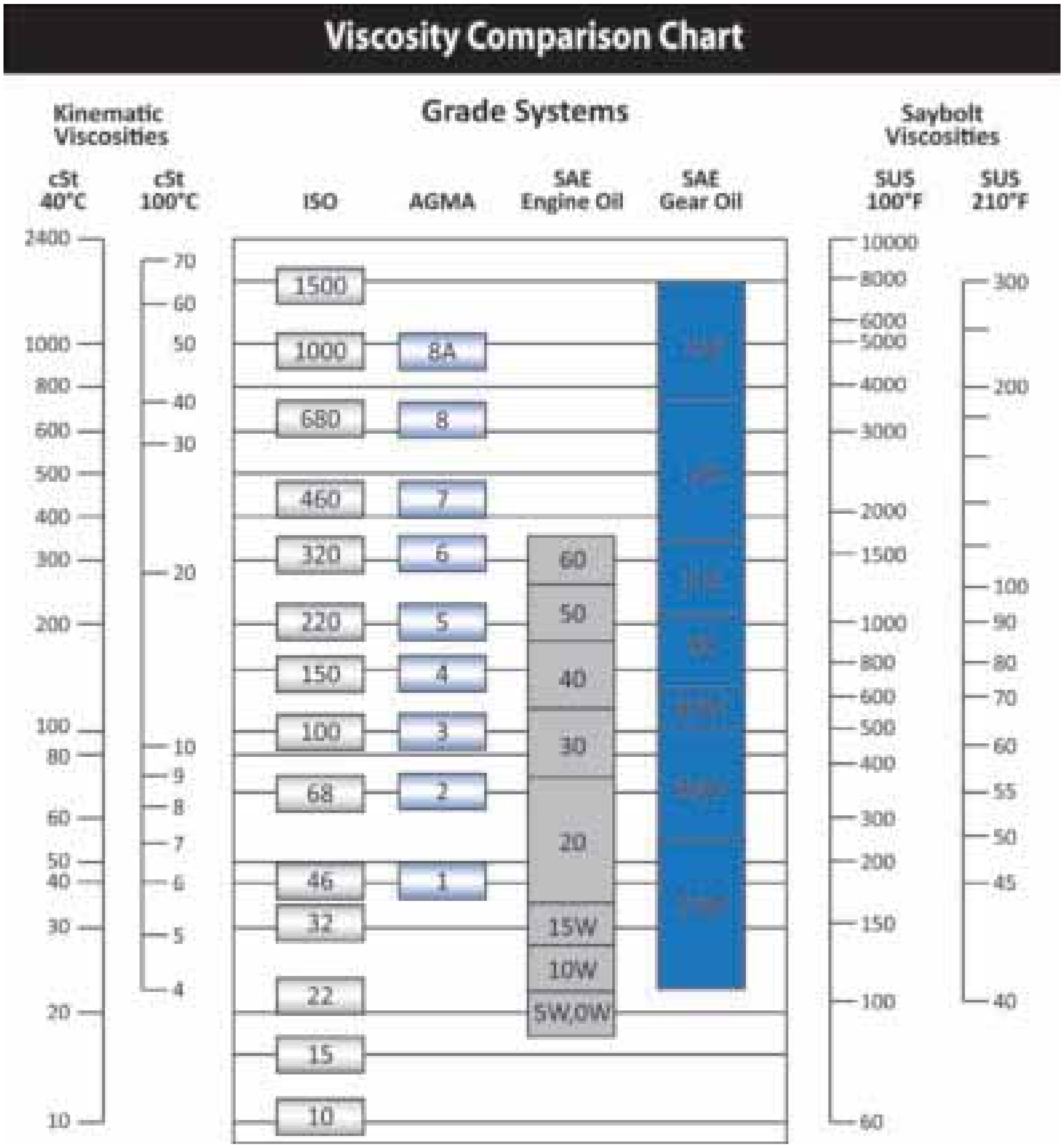

Figure 1.5
Comparison of the various viscosity grading systems. SAE gear oils of similar viscosity to SAE engine oils have a higher grade number.

Service Types: Normal and Severe

Figure 1.6
Common OEM *severe service* operating conditions include frequent towing, hilly/mountainous driving, fleet service and dusty and dirty environments.

Transmission fluid change intervals are based on the service duty of the transmission; however, the definitions for normal and severe service vary by manufacturer.

Service definitions can be found in owner's and service manuals and should be referred to when determining the proper drain interval and fluid requirements for the transmission. AMSOIL-recommended product intervals are outlined in the Product Recommendation and Drain Interval Chart (G1490) or in the relevant AMSOIL product data bulletin.

Refer to www.amsoil.com for details.

Aftermarket ATF Additives

Unlike the oil industry, which is regulated by the API, there is no board to oversee aftermarket additives. This should be taken into consideration when purchasing or adding unknown chemistry to vehicles.

AMSOIL drivetrain fluids and gear lubricants have precisely balanced additive chemistries that can be negatively affected by adding aftermarket additives. Aftermarket additive chemicals can shorten the life of the lubricant and can result in costly damage to the drivetrain.

While aftermarket transmission fluid additives may provide short-term benefits, they typically cause harmful chemical imbalances that result in increased wear and corrosion to the drivetrain. Some aftermarket additives have been shown to increase the cold-temperature viscosity of transmission fluids, impairing fluid flow in the transmission during cold starts.

Section Review

1. What is the primary function of a vehicle's drivetrain?

____

____

2. Aftermarket additives can change the viscosity of a drivetrain fluid.

   True or False

3. Describe a business opportunity in your hometown for selling a drivetrain fluid.

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Mobile Drivetrain Fluids: Section 2
Drivetrain Components

Introduction

Section 2 details the use of gears and gear lubricants in automotive systems, the major components of the drivetrain system and basic operation and lubrication requirements.

This section ends with a technical introduction to transaxles.

Section Objectives

After studying Section 2, you should understand and be able to explain the following terms and concepts:

1. Five primary functions of gears in a mechanical system
2. Concept of ‘torque’
3. Principle of gear ratios
4. Role of the transmission in a vehicle’s drivetrain
5. Function of the transfer case and where it’s found
6. Understanding of the open, limited-slip and locking differential
7. Function of a transaxle unit

Section Keywords

The following keywords are defined in this section. Pay particular attention to their explanations as these concepts will serve as building blocks for future lessons.

Differential
Gear Multiplication
Gear Ratio
Gear Reduction
Limited-Slip Differential
Locking Differential
Open Differential
Power-Takeoff
Torque
Torque Multiplication
Torque Reduction
Transaxle
Transfer Case

Gears, Gear Types and the Mechanical Advantage

Gears are found in many useful devices such as motorized tools, meters, electronics, clocks, cars and trucks. Gears' key advantage is their ability to transfer energy in a consistent manner and increase and decrease that energy as needed.

Drivetrain gear set design varies. Different gear styles and orientations are used depending on the need for rotational speed, degree of gear reduction, torque loading and directional change. An understanding of the gears and forces involved in their operation will provide a better understanding of the lubricants necessary to ensure proper operation and durability.

Simply put, gears are valuable because they accomplish one or more of the five primary functions of mechanical rotation:

1. Reverse directions
2. Change speeds
3. Transfer to a different axis
4. Synchronize between separate axes
5. Multiply or reduce torque

All of these functions occur in the drivetrain system by a variety of gear types.

Torque, the force required to rotate an object, is produced in the drivetrain on a near-constant basis. A fluid barrier is used to help drivetrain components withstand this torque. The fluid must also absorb, reduce and disperse the energy. Without a fluid barrier to dissipate the energy, gears and other mechanical components would inevitably break down after minimal use. It is the lubricant that gives these mechanical components lasting power.

Drivetrain Gear Types

All gear types require lubrication to protect them from friction and wear. Yet, there are certain gear styles that have greater wear protection and extreme-pressure (EP) protection requirements than others. The following is not a complete list of all gear types, but explains the most common gears found in drivetrain assemblies.

Spur (Straight cut)

Spur gears are widely used in parallel shaft applications due to their low cost and high efficiency. Spur gears transmit minimal sliding action as they mesh with each other, so they are usually used in low-speed applications. Only one pair of teeth makes contact at a given time, which limits the load capacity of the spur gear. Limitations of the spur gear include excessive noise and backlash during high-speed operation.

Helical

Helical gears have teeth that are cut at an angle toward the gear face. Contact between the teeth of helical gears is gradual; the teeth begin to make contact at one end and touch the other end as the gear rotates. Because the helical gear teeth engage gradually, they operate more quietly and have a higher load capacity than spur gears. Helical gears are used in manual transmissions to transmit power to parallel shafts.

Spiral Bevel

Spiral bevel gears have curved, oblique teeth that are cut in a spiral configuration. Spiral bevel gears are used to transmit power between perpendicular (90°) shafts. The spiral configuration of the gear teeth allows more teeth to make contact during mesh and greatly increases the gear's load capacity. When used in a differential, spiral bevel gears are referred to as hypoid gears.

When spiral bevel gears mesh, the teeth make sliding contact against each other, which typically requires extreme-pressure fortification to provide sufficient wear and loading protection because most of the lubricant is wiped away.

Planetary (Combination of Spur Gears)

Planetary gear sets feature a specialized type of gear arrangement consisting of a large outer gear with a number of smaller, meshed gears nested inside of it. Planetary gears are an important component of automatic transmissions and provide gear ratio changes to accommodate driving conditions.

Different gear combinations engage to achieve the desired torque, speed and directional output. Bands are used to engage and disengage the gears so they do not have to physically disconnect from each other. The bands lock and unlock the planetary gears so they can either be part of the gear train, or held stationary.

Gear Ratios and the Mechanical Advantage

A *gear ratio* is the relationship between the number of teeth of two mated gears. It measures the number of rotations a gear makes relative to its mated gear. For instance, Figure 2.1 shows two mated gears with a 1:1 gear ratio. These gears have the same number of teeth and will therefore rotate at the same speed. The ratio 1:1 implies that for every complete rotation the drive gear makes, the driven gear also makes one complete rotation. Different size gears are mated together to change speed and torque output.

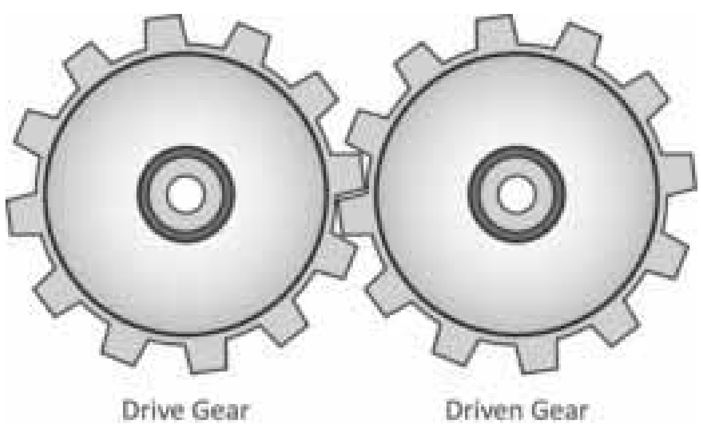


Figure 2.1
1:1 gear ratio

Figure 2.2 shows a 1:2 gear ratio. The drive gear is twice the size of the driven gear. For every rotation the drive gear makes, the driven gear rotates twice. A 1:2 gear ratio describes a ***gear multiplication/torque reduction*** because the output speed is faster and the load capacity is reduced.

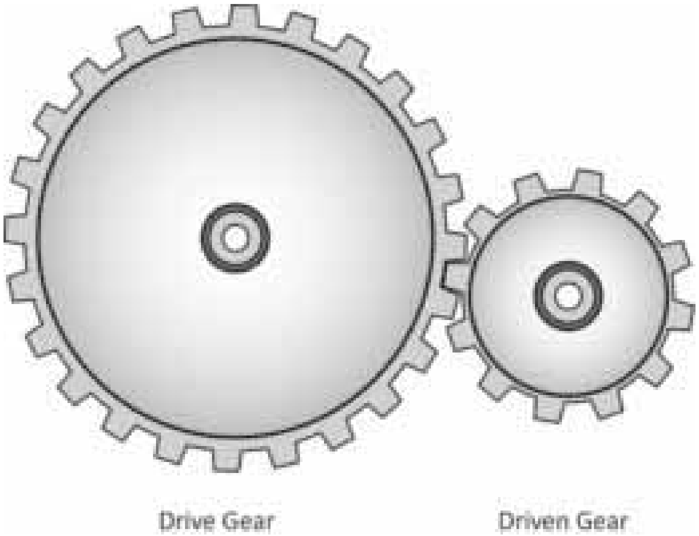


Figure 2.2
1:2 gear ratio, gear multiplication/torque reduction

Figure 2.3 shows a 2:1 gear ratio. The drive gear is half the size of the driven gear. A 2:1 gear ratio describes a ***gear reduction/torque multiplication*** because the output speed is slower and load capacity is increased.

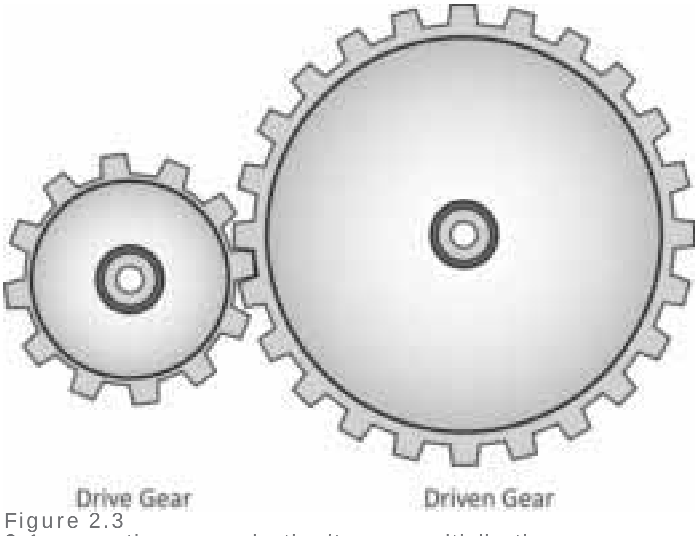


Figure 2.3
2:1 gear ratio, gear reduction/torque multiplication

Simply stated, the driven gear is capable of moving two times the load compared to the drive gear, which is a direct result of the gear ratio between the two mated gears.

The mechanical advantage of multi-ratio gear trains allows speed and load outputs to be tailored as gears of different sizes are mated together.

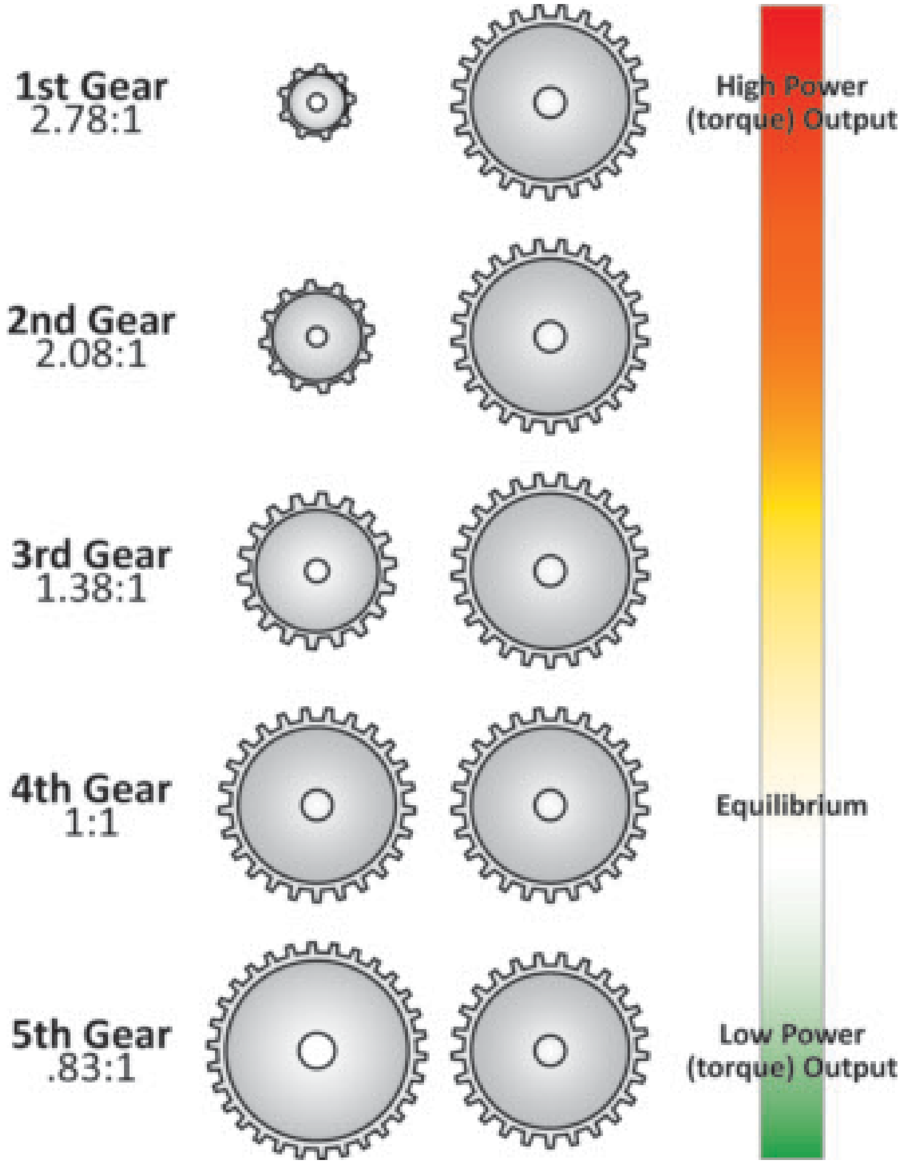


Figure 2.4
Gear ratios and torque output as they relate to a vehicle's transmission (illustrative purposes only)

Figure 2.4 illustrates the concept of gear ratios and how they affect the torque output of a transmission. The gears on the left represent the drive gear, while the gears on the right are being driven.

Gears 1 - 3 are low gear ratios where gear reduction/torque multiplication occurs. The lower the gear, the easier it is for the engine to produce power and move the vehicle from a standstill; however, while lower gears produce more power, they restrict how fast the vehicle can travel.

In fourth gear, speed and power reach equilibrium. Fifth gear represents gear reduction/torque multiplication. While the power output of fifth gear is lower than first gear, it allows the vehicle to travel at a much faster speed.

Drivetrain Components

This portion of section 2 describes why vehicles need a transmission and outlines the benefits they provide for energy efficiency and fuel use.

Why is the Transmission Necessary?

Transmissions transfer the engine's power to the wheels and provide the ability to increase and decrease that power – torque multiplication or torque reduction – and can do so at varying speeds.

Changing gears from first to third is an example of torque multiplication where the power output of the transmission decreases, but the speed output increases.

Energy Transfer from Engine to Wheels: Synchronize Rotation Speed

In order to understand the true need for the transmission, it is important to first discuss an inherent limitation of the internal combustion engine. Internal combustion engines operate within a particular range of revolutions per minute (rpm).

Internal combustion engines are capable of a relatively wide range of rpm, generally 600 – 7,000. On the other hand, the wheels have a limited rotational speed, generally 0 – 1,800 rpm.

The transmission can reconcile these inherent speed limitations, allowing the wheels to increase to an optimal driving speed while allowing the engine to operate at an efficient rpm. In other words, the transmission lets the wheels rotate as fast as the driver wants while allowing the engine to rotate at a speed that maximizes fuel use.

As driving conditions change, the torque and speed required by the wheels differ. Changing gears allows the engine to maximize the amount of work it is doing while using fuel efficiently.

Newer vehicles are being engineered with six, seven and eight available gear ratios. These additional gear ratios provide maximized engine efficiency over a wider range of speeds.

Both automatic and manual transmissions are designed to achieve maximized fuel efficiency for various driving conditions. The manner in which this is achieved varies to some extent. Sections 3 and 4 cover the differences between manual and automatic transmissions in detail.

Transfer Case

The *transfer case* is used in four-wheel drive (4WD) systems to divide the torque output of the transmission to the front and rear axles. Transfer cases are also installed in all-wheel drive (AWD) vehicles and are typically attached to the rear of the transmission.

The transfer case is able to divide transmission torque by using gears or chains to power output shafts that connect the vehicle's front and rear drive axles. The AWD/4WD condition is achieved when both front and rear axles are engaged.

A transfer case can be gear driven or chain driven. Gear driven designs are more durable and are usually used on large truck applications. Chain driven transfer cases are lighter and operate more quietly; they are usually installed on compact and full-size trucks and SUVs.

Automatic Transfer Case Operation

Transfer cases can be operated with a selector lever or electronically controlled push button. Both styles allow the operator to choose between 2WD and 4WD modes. Some transfer cases allow the operator to select different gear ratios, typically *high* and *low*.

Full-time transfer case units remain in 4WD until the vehicle reaches a predetermined cruising speed, at which point they change to 2WD for safer handling. For instance, the New Process 203 transfer case unit remains in 4WD until about 30 mph. Generally, 4WD vehicles transfer power only to the rear axle during normal operation, and the front axle is engaged during the 4WD mode.

Vehicles with a 2WD/4WD selector lever operate differently from those equipped with a full-time transfer case unit. In two-wheel-high (2H) mode, only the rear axle is driven. During the four-wheel-high (4H) mode, the transfer case divides torque to both the front and rear drive axles and allows the axles to rotate at different speeds.

In the 2L/4L (low gear mode), the transfer case engages a second set of reduction gears that locks the axles together so they rotate at the same speed. This condition, while not optimal for high-speed driving, is well-suited for off-road conditions where steep grades and uneven terrains are maneuvered.

Manual Transfer Case Operation

The ability to change drive mode (e.g. from 4H to 2H) varies depending on transfer case design. The internal components of the transfer case responsible for changing drive mode dictate most of the fluid property requirements for the unit.

For a 4WD vehicle with a manual transfer case, engaging and disengaging the front axle requires the vehicle to decelerate. Many newer truck manufacturers advise shifting the transfer case gears below speeds of 3 mph.

Automatic transfer case units are most common on newer vehicles and can be operated at faster speeds. They are electronically actuated and use clutches to transfer rotation to the drive shaft.

Lubricant Requirements

The gears and chains of the transfer case endure a majority of the stress during extreme operation and off-road conditions such as snow plowing or rock climbing.

Shift-on-the-fly automatic transfer case units can shift between 2WD and 4WD while moving. The shift-on-the-fly transfer case uses a synchromesh unit that has specific additive requirements for friction and copper corrosion protection.

Refer to owner and service manuals for transfer unit specification requirements. AMSOIL formulates a number of lubricants that meet most application requirements. The AMSOIL Online Lookup Guide can be used to determine fluid equivalents that meet or exceed specifications for most applications.

Differential

The *differential* divides rotation from the drive shaft to the two sides of a vehicle's drive axle in order to turn the wheels. Different differential designs handle the division of torque differently, and these differences affect vehicle handling in certain conditions.

The *open differential* allows the wheels on opposite sides of the axle to turn at different speeds, or slip. By allowing the opposite sides of the drive axle to slip, vehicle handling during cornering is improved.

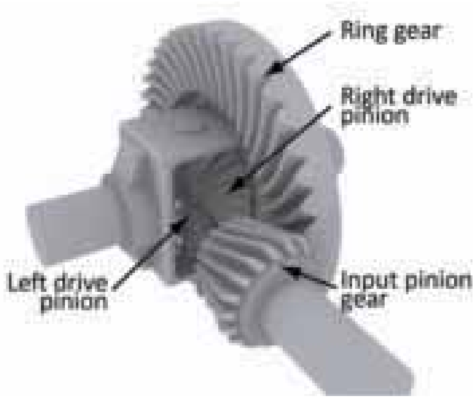


Figure 2.5
Open differential

While making turns, the vehicle's outer wheel travels a farther distance than the inner wheel. If the axle were locked so both wheels were forced to turn at the same speed, the outer wheel would drag and hop along the ground because it would not be able to rotate fast enough. This would put excessive wear on the outer wheel and its components and create unpredictable and unsafe driving conditions.

Because open differentials transfer torque to the wheel offering the least amount of resistance, they cannot transfer torque to the opposite wheel in low-traction scenarios, such as a wheel losing traction on a piece of ice. This restriction of torque transfer prevents the vehicle from moving.

The limited-slip differential was developed to overcome this limitation; it is designed to transfer torque to the opposite wheel in low-traction scenarios.

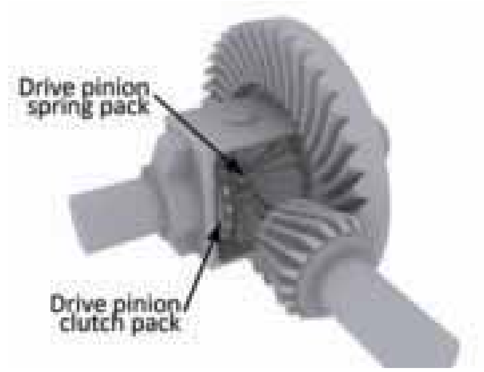


Figure 2.6
Limited-slip differential

Limited-slip differentials operate in a similar manner to open differentials by allowing the wheels on opposite ends of the drive axle to rotate at different speeds during cornering. However, in low-traction scenarios, the *limited-slip differential* transfers torque from the wheel offering the least resistance to the opposite wheel. It is designed to provide the wheel with enough traction to move the vehicle. If a wheel loses traction and slips, a spring pack and set of clutch packs are used to lock and engage the opposite side of the drive axle so that the opposite wheel rotates.

A *locking differential* permanently locks the two sides of the drive axle together and does not allow them to slip at all. Locking differentials produce extra wear on the drivetrain and tires during cornering and are not used in street applications for this reason.

Off-road applications often use locking differentials because driving surfaces are typically soft and inflict little damage to tires during cornering.

Extreme Pressure

The operating environment within the differential is extremely harsh. High temperatures are produced as the gears interact, and high levels of pressure strain gears and bearings. To protect the differential in these extreme conditions, lubricants are engineered to have specific characteristics that resist thinning, provide extreme-pressure protection and resist the effects of oxidation.

The meshing gear teeth cause much of the lubricant to be wiped off tooth surfaces. EP additives bond to the surface of the gear teeth to protect them from the pressure. AMSOIL lubricants reduce friction and wear and help prolong component life by providing EP protection with an iron-sulfide barrier.

Extreme Temperature and Thermal Degradation Resistance

Modern vehicles designed for aerodynamics, coupled with larger cabin sizes, restrict the airflow to the differential and cause it to operate at increased temperatures. The increased size and horsepower of modern vehicles subject the differential to high loads that also increase the amount of heat generated inside the unit.

Lubricating fluid for the differential is responsible for adequately cooling the components; however, newer differential sump designs hold less lubricating fluid than previous models. Lubricants used in these newer applications have to perform against these added challenges, and they must do so with less volume.

AMSOIL synthetic lubricants are ideal for these hot environments because of their inherent resistance to high temperatures. The uniform composition provides stability under extreme heat and resists thermal breakdown to maintain an impervious fluid barrier between components.

Rust

Differential housing designs incorporate air vents to accommodate pressure changes as air temperatures fluctuate. When warm air is drawn into the cool differential housing, condensation forms on surfaces and encourages rust and corrosion.

In addition to eating away metal surfaces, rust and corrosion shed abrasive particles that damage the inner workings of the gear system. These harmful particles cause minute pitting and scoring as the gears mesh, which eventually results in gear failure.

AMSOIL fluids are treated with a robust rust-inhibitor package that combats rust development in the drivetrain system.

Foaming

Foaming poses a serious threat to the differential by introducing excessive amounts of compressible air into the fluid. It can be caused by over- or under-filling the sump and incompatible base oils or additive packages. In addition to compromising the lubricant barrier and permitting increased friction between components, foam increases operating temperatures by acting as a heat insulator.

AMSOIL transmission fluids help prevent the formation of foam with defoamants that reduce the surface tension of bubbles. This ensures that any foam development will rapidly dissipate to prevent excessive friction and heat retention.

Friction

Limited-slip differentials require controlled frictional properties for responsive clutch engagement and disengagement. Friction modifiers reduce the potential for clutch chatter that damages clutch plate surfaces. Chatter is the unintentional stick-slip engagement of the clutches and is caused by a lack of proper friction modifiers in the lubricant.

AMSOIL lubricants are fully fortified with controlled friction modifiers to maximize friction surface performance. Friction modifiers allow clutch plates to engage and disengage properly and ensure smooth and safe differential operation.

Transaxles

The *transaxle* is a compact component that combines the transmission, differential and associated components of the driven axle into one integrated assembly. Transaxles are typically used in applications where the engine and the drive axle are on the same end of the vehicle, such as in front-wheel-drive cars. Typically, gears in the transaxle are spiral bevel, spur or helical.

When the engine, transmission and differential are separate units, a number of directional changes are required to transfer torque through the drivetrain assembly. When these components are separate, the engine is perpendicular to the driven axle, requiring a 90-degree turn. Figure 2.7 illustrates the power flow in a vehicle where engine, transmission and differential are separate components. Notice how the direction of torque from the driveshaft to the final-drive axle requires a 90-degree turn. A perpendicular change in rotation generally requires the use of hypoid gears that require a heavy-duty, EP-fortified lubricant.

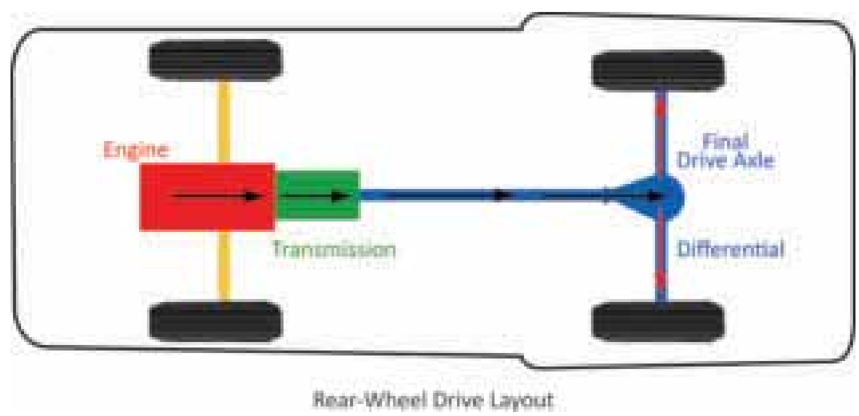


Figure 2.7
Rear-wheel drive configurations typically accomplish a 90° turn in the differential by using hypoid gears, which require an EP-fortified fluid.

In most cases, transaxles eliminate the 90-degree directional change because the engine, transmission and differential are oriented in-line with the final drive axle, not perpendicular to it. Figure 2.8 illustrates the direction of energy transfer from the transaxle to the final drive axle. Notice how the direction of energy transfer is in-line from the transaxle

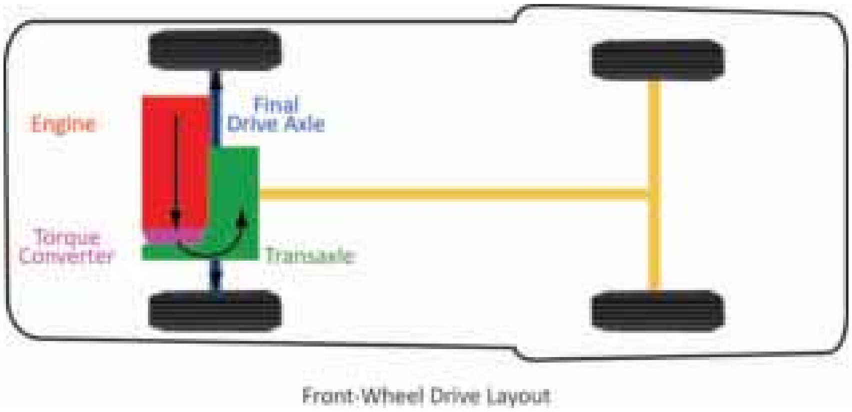


Figure 2.8
The transaxle eliminates the need for an EP-fortified fluid because the engine and transmission are in-line with the drive axle, using helical gears that do not have EP requirements.

to the final drive axle. Because the energy transfer is in-line, helical gears can be used to power the drive axle. Helical gears have less demanding requirements for wear and EP protection than hypoid gears, and can often be adequately lubricated by an automatic transmission fluid (ATF).

Lubrication

Lubricant performance must provide protection for both the transmission and synchronizer elements of automatic transaxle units, making API GL-4 and GL-5 gear lubes unsuitable due to their EP additive content. Typically, FWD automatic transaxles can use an automatic transmission fluid. AMSOIL offers two automatic transmission fluids formulated to exceed manufacturers' specifications: Multi-Vehicle Automatic Transmission Fluid (ATF) and Synthetic Fuel Efficient Automatic Transmission Fluid (ATL).

Manual transaxles often require a transmission fluid that meets gear lubricant specifications. For example, some manual transaxles specify an API Service GL-4, GL-5 or MTF fluid.

Refer to owner and service manuals to determine specific lubrication requirements. The AMSOIL Online Lookup Guide is a tool to cross-reference appropriate fluids that meet and exceed specifications in most applications.

Power Takeoff Unit

More commonly referred to as a PTO, the ***power takeoff*** assembly is used to power an accessory unit that has nothing to do with moving the vehicle. Power takeoff units are generally found on larger, heavy-duty equipment like refuse haulers and farming equipment.

Figure 2.9
A power takeoff unit attached to a large vehicle
Image used with kind permission from "Factory Direct" a division of "Seneca Tank."

PTOs use gears that are mated directly to the transmission to convert its energy to power the accessory unit. Some examples include a PTO-driven winching system, a tilting bed on a dump truck, water pumps on fire trucks or garbage compactors on refuse haulers. PTO units are most often used to power hydraulic systems.

PTO units in manual vehicles are typically mounted to the vehicle's transmission and are driven by a counter shaft or reverse idler gear. In automatic transmissions, the unit is often driven before the torque converter.

PTO units do not have a dedicated lubricant sump and use the transmission's fluid source for lubrication.

Section Review

1. Name three of the five primary functions of gears in a mechanical system.

   ____

   ____

2. To achieve torque multiplication, the drive gear would be larger than the driven gear. True or False

3. To achieve a torque reduction, the drive gear would have to be _______________ than the driven gear

4. List the two functions of the transmission.

   ____

   ____

5. What is the purpose of a transfer case?

   ____

   ____

6. Describe the limitation of the open differential when one of the drive wheels has no traction.

   ____

   ____

7. How does the limited-slip differential overcome the problem described in Review Question #6?

   ____

   ____

8. In what applications would a locking differential be necessary?

   ____

   ____

9. Why can rust formation jeopardize gear integrity?

   ____

   ____

10. Why are EP-fortified lubricants generally not used in transaxle applications?

   ____

   ____

Mobile Drivetrain Fluids: Section 3
Manual Transmissions

Introduction

Section 3 begins with a description of the components and operation of manual transmissions. Manual transmission components that rely on manual transmission fluid (MTF) for proper operation are discussed, with an emphasis on fluid requirements and additive considerations.

Section Objectives

After studying Section 3, you should understand and be able to explain the following terms and concepts:

1. Function of the manual transmission
2. Difference between a manual transmission and automatic transmission
3. Difference between the constant-mesh manual transmission and the sliding-gear manual transmission
4. The function of the synchromesh unit in the manual transmission and its lubrication requirements

Section Keywords

The following keywords are defined in this section. Pay particular attention to their explanations as these concepts will serve as building blocks for future lessons.

Clutch
Sliding-Gear Manual Transmission
Spline
Synchromesh Unit
Synchronized Manual Transmission

Introduction to Manual Transmissions

The manual transmission transfers engine power to the vehicle's final drive components. It is characterized by a driver-operated clutch that physically links the engine and transmission.

This section focuses on the general operation of the manual transmission and the importance of proper lubrication and controlled frictional properties.

Manual Transmission Components

The *sliding-gear manual transmission* consists of unsynchronized gears in the gearbox. Although the sliding-gear manual transmission is no longer used in modern vehicles, a basic understanding of its operation serves as the foundation for understanding the operation and lubrication requirements for the modern *synchronized manual transmission*.

Major components of the manual transmission are identified below. Refer to Figure 3.1 on the following page for a visual representation.

Clutch
The clutch physically links the engine to the transmission and is controlled by the operator via the clutch pedal. The engaged clutch transfers rotation from the engine's crankshaft to the transmission's layshaft so that they rotate at the same speed.

Layshaft/Cluster Gear
The layshaft is a solid component that holds a gear mate for each drive gear on the output shaft. This entire unit is often referred to as the "cluster gear."

Output Shaft
The output shaft holds all of the drive gears, dog gears and synchromesh units. It transfers rotation to the driveshaft.

Drive gears
Helical drive gears are located on the output shaft; they ride on bearings that allow them to spin freely on the output shaft. Each gear contains a spline and teeth used to lock the drive gear to a dog gear. A *spline* is a mechanical key that is attached to one of two connected parts.

Synchromesh *(Not included in sliding-gear manual transmissions)*
The synchromesh unit (Figure 3.2) is a conical, bronze ring attached to each drive gear. It's friction surface matches the speed of rotation between the drive gear and dog gear to provide smooth gear initiation.

Dog Gear *(Not included in sliding-gear manual transmissions)*
Sometimes referred to as the dog collar, the dog gear contains teeth that lock the selected drive gear to the output shaft.

Selector Fork
The selector fork moves the dog collar to the selected drive gear, it is controlled by the operator via the gear selector lever.

Gears

Helical gears are usually used in manual transmissions because of their quiet operation and high load capacity. The helix pattern of the teeth provides superior tooth strength that makes them ideal for manual transmission applications.

The lubricating fluid minimizes gear wear and heat buildup to improve gear efficiency and inhibit the corrosion of gear surfaces. A high-quality lubricant is critical for optimal protection and performance because the relative motion between the gears squeezes out the oil between gear teeth.

Straight motor oil or automatic transmission fluids typically provide enough protection for most manual transmission parallel shaft applications.

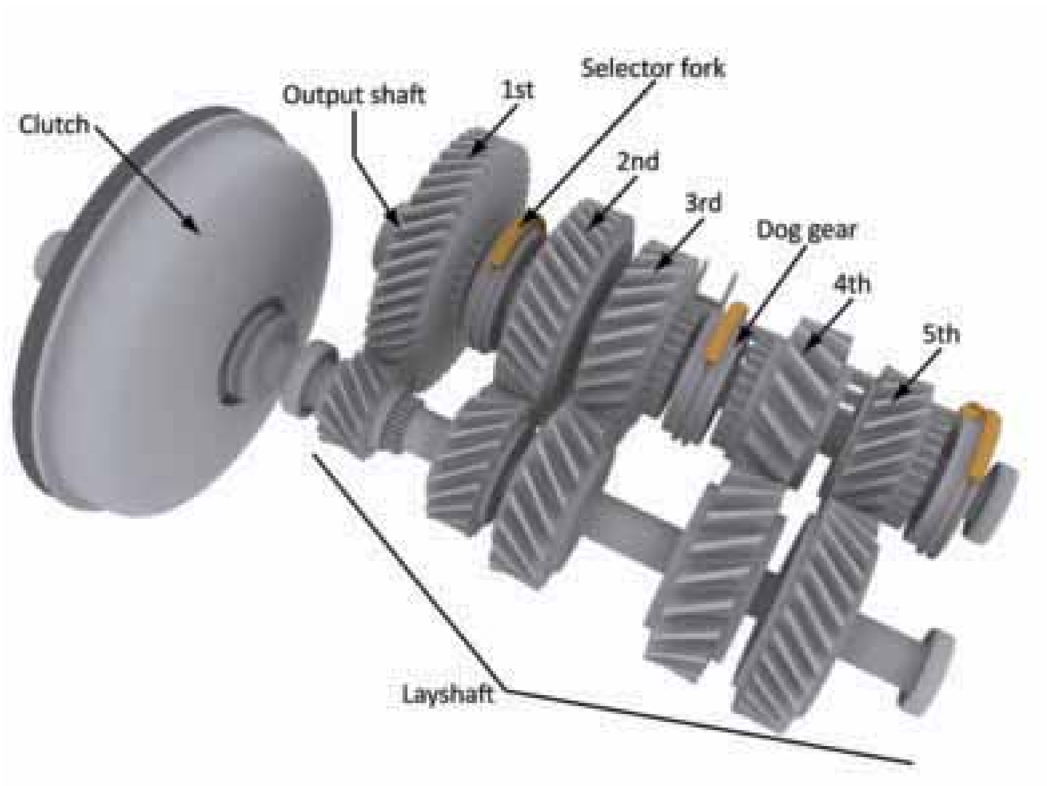


Figure 3.1
Manual transmission components

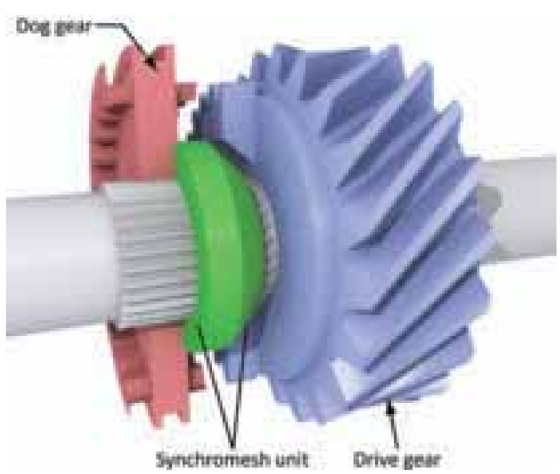


Figure 3.2
Synchromesh unit

GL-4 lubricants may be specified for applications that require anti-wear and mild-EP additive content. GL-5 lubricants may be specified for applications that require high EP content.

Clutch

The *clutch* physically links the engine to the transmission and controls the transfer of power between the components. It is connected and disconnected from the engine via an operator-controlled clutch pedal that allows the drives to change gears while the vehicle is moving. When the clutch is disengaged, the engine can remain running while the vehicle is stopped. When the clutch is engaged, a solid physical connection between the engine and transmission is achieved by the clutch's friction materials.

Operation

Clutch components work together to control engagement and disengagement of the clutch plate to the engine's flywheel.

Figure 3.3
Typical manual transmission clutch assembly

The flywheel is located to the rear of the engine and is attached to the crankshaft. The flywheel helps absorb shock impulses and provides momentum.

The clutch plates are located between the flywheel and the pressure plate; they create the physical link between the engine and transmission when the clutch is engaged.

The pressure plate is bolted to the flywheel and rotates at engine speed. When the clutch is engaged, the pressure plate pushes the clutch plates against the flywheel to create a solid connection.

The surface of the flywheel is machined to have frictional characteristics so that it will mate with the clutch plate properly and prevent slipping.

Section 3

Unsynchronized Manual Transmission Operation

Sequence of a Gear Change in an Unsynchronized Manual Transmission

1. While the vehicle is moving, a single drive gear is mated with the selected gear on the layshaft.

2. During a gear change, the selector fork moves the drive gear to the desired layshaft gear.

3. The driver must manipulate engine rpm speed so that its matches the speed of the layshaft. Engine speed can be reduced and the transmission can move into a lower gear, or engine speed can be increased by opening the throttle (stepping on the gas pedal) and the transmission can move into a higher gear. The sliding gear mates with the various sized layshaft gears to achieve different gear ratios.

Synchronized Manual Transmission Operation

Sequence of a Gear Change in a Synchronized Manual Transmission

1. While the vehicle is moving, the selected drive gear is locked to the output shaft by the dog gear. All other gears are spinning freely on the output shaft at engine speed.

2. During a gear change, the selector fork moves the dog gear to the selected, free-spinning gear.

3. The inner surface of the dog collar makes contact with the synchromesh unit fixed to the drive gear. Friction between the dog gear and synchromesh material force the drive gear and output shaft to match speeds while simultaneously locking the drive gear to the output shaft.

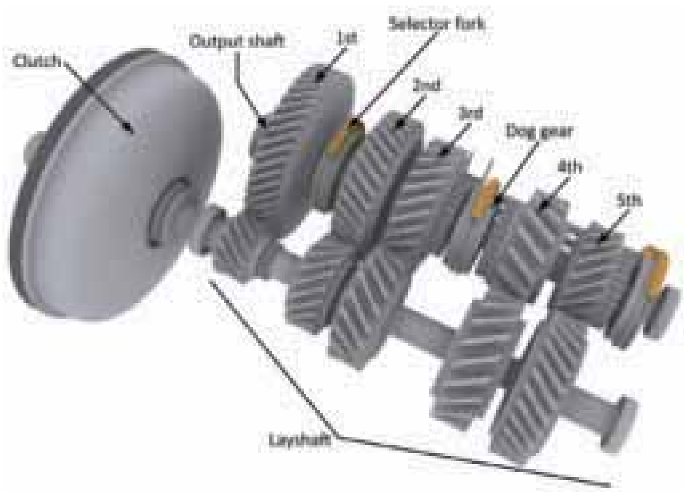


Figure 3.4
Layout and typical components of a synchronized manual transmission

The illustration to the left shows a synchronized manual transmission. Notice how gears 1 – 5 on the output shaft are mated to a gear on the layshaft. In an unsynchronized sliding-gear manual transmission, only one gear would ride on the output shaft, and it would have to slide into place to mate with the operator-selected gear on the layshaft.

The synchronized manual transmission is characterized by multiple drive gears on the output shaft. In contrast, the sliding-gear manual transmission has a single drive gear on the output shaft that must physically slide into position.

Just as some finesse is required to match gear speeds in a sliding-gear manual transmission, the dog gear and drive gear on the output shaft must also match speeds to ensure the gear change is smooth as they lock together. The synchromesh unit is used to accomplish this task.

The *synchromesh unit* – often referred to as the synchro, synchronizer or synchromesh gear – is a key element to the synchronized manual transmission and is responsible for matching the speeds between the free-spinning drive gear and the output shaft. Without the synchromesh unit, the gears spinning at different speeds would clash as they try to mate.

Synchromesh Operation

When the selector fork moves the dog gear to the selected drive gear, the inner surface of the dog gear makes contact with the synchromesh unit. The friction between the two surfaces causes the components to match speeds and allows the gears to mate without clashing. As the speeds of the components synchronize, the dog gear locks the selected drive gear to the output shaft, causing the output shaft to rotate at engine speed. The entire process happens relatively quickly and in correctly operating transmissions, goes unnoticed.

If the gears are shifted too quickly, a grinding noise can be heard; however, it is not gears that are grinding. Quick shifts prevent the synchromesh unit and dog gear from completely synchronizing speeds, so the dog gear's teeth clash with the drive gear's dog teeth.

Synchromesh Lubrication

Properly engineered lubricants are required for the synchromesh unit to operate properly. Lubricant viscosity and friction properties are extremely important for the proper operation of the synchronizer unit. Viscosity that is too high could prolong the gear-shift process and increase friction and heat inside the component. Viscosity that is too low could cause the synchronizer and dog gear to move into place too quickly. The fluid's frictional properties must be precisely engineered. If the lubricant is engineered to be too slippery, it can prolong synchromesh transfer and cause the friction material to wear down prematurely.

Typically, the lubricant cannot contain high levels of anti-wear and EP additives because they will deteriorate synchromesh materials and disrupt gear engagement.

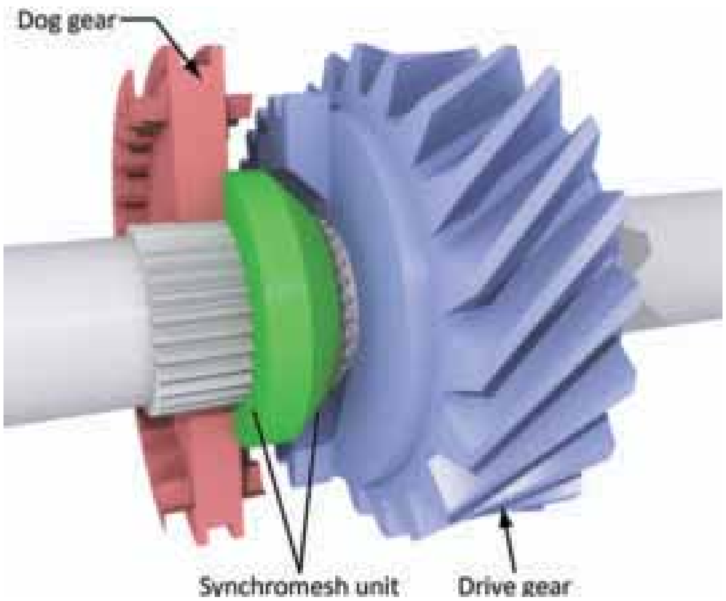


Figure 3.5
Synchromesh unit

Common Manual-Transmission Lubricants

Common Manual Transmission Lubricants

Requirements & Product Specifications

Modern manual transmissions have specific requirements for lubricant and additive properties. Therefore, selecting the appropriate grade of lubricant with the proper additive package is extremely important when replacing the transmission's fluid.

Manual transmissions may call for a motor oil, an ATF, a GL-4 or GL-5 fluid, or MTF synchromesh fluid. Motor oils are common manual transmission lubricants in older vehicles, but they generally do not offer adequate protection in modern transmissions. When servicing modern vehicles, an ATF, GL-4 or GL-5 gear lubricant, MTF synchromesh or specialty transmission fluid will most likely be required.

Refer to the API Automotive Service Classifications for Gear Oil Chart on page 6 (Figure 1.2) for a detailed explanation of these lubricant classifications.

When replacing the fluid in a manual transmission it is important to use a fluid that is recommended for the original equipment manufacturer (OEM) fluid specifications, including viscosity grade and additive package.

OEM Fluids

OEMs often specify their own branded fluid for service-fill use. These fluids are engineered to meet particular viscosity and frictional performance that support the components and materials incorporated in the transmission. AMSOIL formulates fluids that go beyond OEM performance specifications, providing maximized performance and protection for equipment.

ATF

Automatic transmission fluid is increasingly being specified for manual transmissions because it provides improved shift qualities at low temperatures. The low viscosity of ATF provides fuel efficiency gains over typical gear lubricants. The additive package in typical ATF provides the necessary anti-wear, oxidation and corrosion protection required of the manual gearbox; however, older manual transmissions usually require a higher-viscosity fluid.

Synchromesh Fluids

Synchromesh fluids are engineered for controlled frictional properties. These specialized formulations facilitate proper synchromesh engagement and provide the correct balance of lubricity and friction to enhance the manual transmission's service life.

OEMs formulate these specialty fluids for certain transmission models. For instance, the GM Synchromesh Transmission Fluid is a mineral-based lubricant specified for Tremec and New Venture Transmissions because it has been fortified with special friction modifiers. AMSOIL Manual Synchromesh Transmission Fluid (MTF) is suitable for this and most GM synchromesh applications. Refer to the applicable AMSOIL data sheet or the AMSOIL website for specific and up-to-date information on product specifications.

Gear Lubricants

AMSOIL Synthetic Manual Synchromesh Transmission Fluid

AMSOIL Synthetic Manual Synchromesh Transmission Fluid is a premium synthetic lubricant designed for manual transmissions and transaxles.

It stands up to rigorous transmission pressures and resists shearing to maintain the film strength required for excellent anti-wear protection of heavily loaded gears.

AMSOIL Manual Synchromesh Transmission Fluid exhibits outstanding performance benefits by reducing friction, heat and wear to increase the operating life of the transmission. Its superior high-temperature stability resists harmful oxidation, varnish and acid buildup. Low-temperature performance improves shift times and transmission response in frigid temperatures.

AMSOIL Synthetic Manual Transaxle Gear Lube

AMSOIL Synthetic Manual Transmission and Transaxle Gear Lube (MTG) is a premium blend of the finest synthetic base oils and high-performance additives. It is formulated to meet the demanding requirements of GL-4 gear lubricants where towing and heavy loading increase stress on transmission gears.

This superior lubricant resists thinning from mechanical shear, providing consistent and durable protection even in the most demanding applications. AMSOIL Synthetic Manual Transaxle Gear Lube is a thermally stable fluid that resists heat and oxidation to inhibit acid and varnish buildup and promote maximum equipment performance. Its robust formulation is engineered to endure high horsepower and quick shifts common in large-displacement engines like those found in muscle cars.

AMSOIL Advantage

Copper Corrosion Resistance

Modern manual transmissions have specific requirements for copper corrosion resistance to protect copper or bronze synchromesh units in the transmission assembly. Anti-wear and extreme-pressure additive combinations must be specifically formulated for these critical components.

AMSOIL Synchromesh Transmission Fluid is compatible with copper and bronze synchronizer materials to provide smooth shift qualities for the life of the fluid.

Smooth Synchromesh Operation

Synchromesh units require specific viscosity and friction properties to function properly and provide smooth and responsive shift qualities. Fluids that impede engagement due to excessive friction produce rough shift qualities, while fluids that are too slippery prolong shift engagement and cause premature wear.

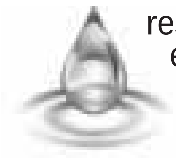
AMSOIL Synchromesh Transmission Fluid is formulated with specific friction modifiers to support synchromesh engagement and sustain optimal operation. Extreme-pressure additives are not included in the formulation.

Heat Resistance

Transmissions housed in cast-iron, such as the NV 4500, retain heat and require a lubricant capable of cooling components during heavy loading and high-torque operation.

While some conventional lubricants thin out from excessive heat, AMSOIL Synthetic Manual Transmission Fluid has excellent high-temperature

Section 3



resistance and maintains viscosity despite extreme heat exposure.

Because synthetic base oils keep equipment cooler than conventional lubricants, oxidation resistance is improved. By helping prevent oxidation, the development of sludge and varnish deposits are significantly reduced, providing responsive shifting and maximized performance.

Cold Temperature Properties

Conventional transmission lubricants tend to thicken when exposed to cold temperatures. Viscosity increases until the fluid can no longer flow, leaving transmission gears exposed to metal-on-metal contact that increases friction and wear and damages gears.

Thick fluids impart viscometric drag, causing the transmission to work harder against fluid resistance. Increased resistance reduces overall transmission efficiency and causes the engine to consume more fuel. A fluid that resists thickening during cold temperatures maximizes fuel economy and enhances equipment operation.

Synthetic base oils have excellent cold-temperature properties; AMSOIL synthetic manual transmission fluids maintain fluidity below -40°F (-40˚C) to coat components with a protective fluid barrier, even in frigid temperatures. Cold-weather fluidity provides reliable starting, smooth gear changes and maximized fuel economy.

Fluid Life Expectancy

Synthetic base oil structures are chemically more stable than conventional oils. Coupled with robust additive packages, AMSOIL synthetic base oils provide exceptionally long life for AMSOIL lubricants.

Section Review

1. What is the function of the clutch in a manual transmission?

___

___

2. What is the function of the synchromesh unit in a manual transmission?

___

___

3. How does the synchromesh unit depend on proper lubrication and frictional properties?

___

___

Mobile Drivetrain Fluids: Section 4
Automatic Transmissions

Introduction

Section 4 begins with an introduction to the components and operation of the automatic transmission. Components that rely on automatic transmission fluid (ATF) for proper operation are discussed, with an emphasis on fluid requirements and additive considerations. Prior fluid specifications and their evolution are also explored, including major driving forces behind specification changes.

Major components, including the torque converter, clutches and clutch packs, the planetary gear system and the valve body are included; fundamental operation and lubrication requirements are described for each. This section concludes with a basic examination of new transmission systems that are coming to market and their projected lubrication requirements.

Section Objectives

After studying Section 4, you should understand and be able to explain the following terms and concepts:

1. Basic function of automatic transmissions
2. How the automatic transmission is distinguished from the manual transmission
3. Fundamental components of automatic transmissions
4. Purpose of OEM fluid specifications
5. Basis for tighter fluid specifications
6. How transmission fluid properties enhance transmission component performance

Section Keywords

The following keywords are defined in this section. Pay particular attention to their explanations as these concepts will serve as building blocks for future lessons.

Clutch Glazing
Slippage
Shudder
Torque Converter
Torque Converter Lockup Clutch

Introduction to Automatic Transmissions

Modern automatic transmissions are designed for high horsepower and torque outputs while providing an enjoyable driving experience characterized by smooth and responsive shift qualities. They differ from manual transmissions in their ability to change gear ratios automatically without driver interaction. They also can accomplish gear changes without a loss of power to the wheels. Automatic transmissions have evolved significantly, with recent focus on improving overall performance and fuel economy.

Automatic transmissions use a complicated system of machinery that includes planetary gears, clutches, torque converter, valve body, elastomeric seals and gaskets. Each component relies on transmission fluid for optimal operation.

Closer inspection of automatic transmissions reveals additional planetary gear sets, including wet clutches and bands that engage the gears. A hydraulic system controls the clutches and bands, and an oil pump supplies the system with fluid.

This section examines the critical components of automatic transmissions, including the lubrication properties required for maximized performance.

OEM Performance Specifications for Automatic Transmissions

OEMs define the lubrication requirements for the transmission; these requirements guide factory- and service-fill fluid properties to ensure proper performance for the life of the fluid.

As automatic transmissions undergo design and hardware changes, fluid specifications often follow suit. For example, GM introduced the DEXRON VI fluid specification to coincide with the development of its six-speed transmission.

Evolution of Common Transmission Fluids

	Timeframe	Back Serviceable	KV @ 100°C	Brookfield @ -40°C	Flash Point (°C)	Foaming (Seq. 1 - 4)	Type
DEXRON	1967						
DEXRON II	1973 - 1993						
DEXRON III	1994	YES To 1949 GM vehicles	Report	20,000 max	170 min	No foam @ 95°C / 5mm @ 135°C max 15 sec collapse time at 135°C	
DEXRON IV	2005	YES	6.4 max	15,000 max	160 min	50/50/50/50	Hydra-matic transmission
Ford F-Type	Pre-1981 Ford (1961 - 1976)						
MERCON	1981 - 1996	YES	6.8 min	20,000	177 min	100/100/100/100	
MERCON V	Certain 1996 - 2007	Limited	6.8 min	5,000 - 13,000	180 min	25/50/25/80	
MERCON SP	2001		5.0 - 6.0	13,000 +/- 2,000 cP	200 min	50/40/50/75	Conventionally shifted 5 & 6 speed trans.
MERCON LV	2006+	NO	6.2 max	12,000 max	160 min	20/50/20/100	
MERCON C							CVT
ATF Plus & ATF +2	1988 - 1997						
ATF +3	1997 - 1999						
ATF +4	1999 - 2005		7.3 - 7.8	10,000	190 min	0/50/0/100	

Figure 4.1
Common U.S. transmission fluids and specification changes over the years
(some fields are blank due to a lack of published information)

Introduction to Automatic Transmissions

OEM Performance Specifications for Automatic Transmissions

Section 4

Oftentimes, OEMs develop exclusive fluid tests that simulate specific oil performance requirements. For example, GM may have a friction test that qualifies its oil; however, it is unique to GM protocol and other manufacturers do not use it.

The frictional requirements of the transmission materials guide fluid specifications. For example, some transmission designs require fluid with more ‘sticky’ qualities while others require a more ‘slippery’ fluid.

A brief summary of how the most common fluids in use in the U.S. have evolved over the years is shown in Figure 4.1.

Fundamental Components of Automatic Transmissions

The following descriptions of automatic transmission components demonstrate function, operation and major lubrication requirements.

Torque Converter

The torque converter performs the same function as a manual transmission’s clutch; it transfers engine rotations to the transmission, which eventually reaches the vehicle’s wheels.

Operation

A *torque converter* is a fluid coupling used to transmit rotation between two components by harnessing the movement of fluid. A simplified way to understand how a torque converter works is to apply the fan-to-fan analogy.

Visualize the two sides of a torque converter as two fans facing each other. The fan on the right is powered by the engine and is called the pump. The fan on the left is not powered and is free to spin; it is called the turbine and is attached to the transmission.

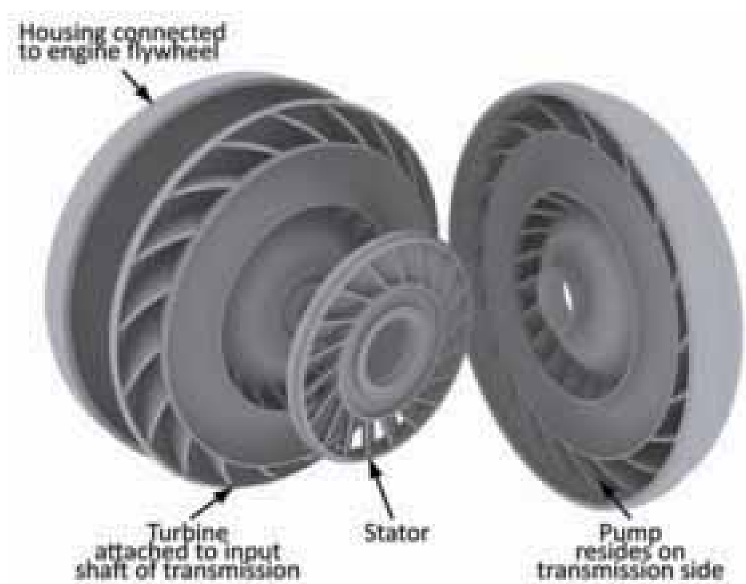


Figure 4.2
The torque converter is a fluid coupling used to transfer engine rotations to the transmission.

The pump directs air into the turbine’s blades and causes the turbine to spin. An actual pump and turbine interact just like this, only fluid is used to transfer the movement between sides. The spinning turbine transfers movement to the transmission.

Centrifugal force inside the spinning pump draws fluid to its outer walls where it is channeled to the turbine. Fluid movement creates a vacuum effect at the center of turbine, which draws the fluid out and back into the pump through a device called the stator, where the cycle repeats.

Slippage occurs between the pump and turbine because the turbine can never spin as fast as the pump side of the torque converter. The slipping between the pump and turbine causes energy loss and fuel-efficiency deficits.

The *torque converter lockup clutch* is used to overcome the slippage between the pump and turbine. The clutch locks the pump and turbine together to maximize fuel economy. It is engaged only during high-speed cruising conditions. The clutch is designed to slip during acceleration and low-speed operation.

Lubrication Requirements

Anti-foam agents inhibit the development of foam that can develop from the rapid and constant churning inside the torque converter. During the slipping phase, the fluid in the torque converter lockup clutch is exposed to high levels of shearing force that can shear the fluid out of viscosity grade. The fluid must be extremely shear stable and resistant to oxidation as it tolerates high shear forces and high temperatures.

Automatic transmission fluids must provide frictional properties that last the duration of the fluid's service life. To suppress excessive vibration and vehicle shudder, the fluid must increase the friction it provides as the speed of the transmission increases. This is referred to as a positive coefficient-of-friction-to-speed relationship.

If the fluid is unable to control friction, the transmission's torque converter clutch (TCC) will rotate faster than its limits and send excessive vibration through the drivetrain to the passenger cabin, which is experienced as vehicle *shudder*. Key performance areas inside the torque converter lockup clutch include smooth engagement and disengagement of friction materials and shudder suppression, as clutch shudder can cause clutch lockup.

Clutches/Clutch Packs

Clutch packs engage various gear combinations in the planetary gear train. They are usually activated by hydraulics, where fluid squeezes the steel plates and clutch packs together.

Lubrication Requirements

Transmission fluid must be shear stable to resist hydraulic pressures. It must also have certain frictional properties so clutches engage properly.

When clutch operation is compromised by clutch glazing, performance and holding capacity decline. Drivers notice clutch slippage and decreased acceleration as the clutch's ability to transfer torque from the engine to the transmission is diminished.

Clutch glazing occurs when transmission fluid heats excessively and reacts with oxygen. The by-products of this reaction develop a varnish, or glaze, on the clutch plate surface, filling in the uneven surfaces with slippery by-products. When the clutch becomes significantly glazed, it no longer provides the necessary frictional characteristics necessary for optimum engagement or disengagement of the friction surfaces.

The lockup clutch in the transmission's torque converter can also suffer from glazing. Drivers may notice an increase in fuel consumption because engine and transmission speeds (rpm) don't match. Another consequence of the engine and transmission not locking together is that engine rotations can surge while traveling at a constant speed.

Because AMSOIL base oils are thermally stable and fully formulated with advanced, controlled friction-modifier additives, clutch friction materials are protected from oxidation and glazing processes over the life of the fluid.

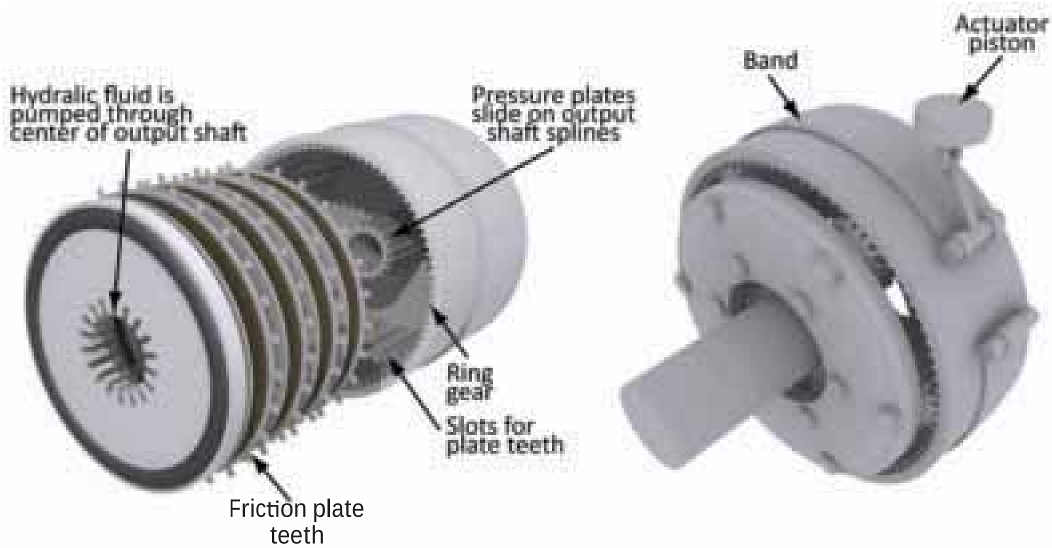


Figure 4.3
Automatic transmission clutches are hydraulically controlled.

Planetary Gears

Automatic transmissions use planetary gears to create all available gear ratios necessary for various driving conditions and generate the low and high gears used to vary torque output. The sun gear, the planet gear and the ring gear are the three main components used to operate the planetary gear train. Each of these gears can serve as the input or output. They can also be locked in a stationary position, if needed. Different

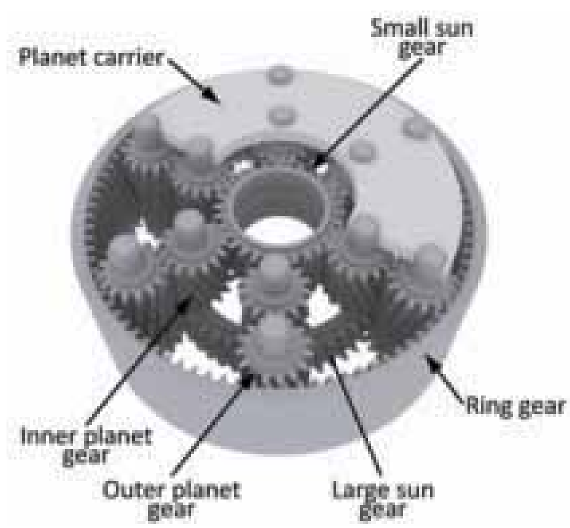


Figure 4.4
Planetary gears of an automatic transmission

combinations of input/output/stationary gears result in different gear ratios.

Torque demands on the gears increase during heavy-duty operation such as hilly driving or towing. These internal forces strain the fluid's ability to maintain a protective fluid barrier against metal-on-metal contact.

Lubrication Requirements

The transmission fluid is responsible for cooling the gears and protecting against wear. Under high load and stressful operation, the fluid protects against scoring, pitting and gear seizure. Rust and corrosion inhibitors protect gear surfaces from chemical degradation. The fluid must be shear stable to resist thinning out from the high-stress operation of the planetary gear set.

Oil Pump

The transmission oil pump is located at the front of the transmission before the torque converter and is typically covered by the oil pan. It circulates and maintains oil pressure in the transmission system.

Oil enters the pump through a filter on the bottom of the oil pan. Fluid travels by pickup tube directly to the oil pump. It is circulated to the regulator and valve body, and then to the rest of the transmission system as necessary.

Lubrication Requirements

Dispersants in the fluid act as solvents to ensure sludge and deposits remain at acceptable levels so they do not impede filter performance and restrict oil flow. Flow restriction in the oil pump can cause sluggish operation or oil starvation that will cause transmission failure.

Valve Body

The valve body is the transmission's hydraulic control center. It is composed of a maze of narrow channels that direct fluid to valves, clutches and bands that initiate gear changes.

Lubrication Requirements

The fluid must have good thermal stability to inhibit sludge and deposits that can interfere with the hydraulic system. Dispersant properties prevent solid contaminants from agglomerating into larger masses that block narrow passages and reduce the functionality of the transmission. Restricted or blocked passages can cause erratic shift qualities and eventual gear loss.

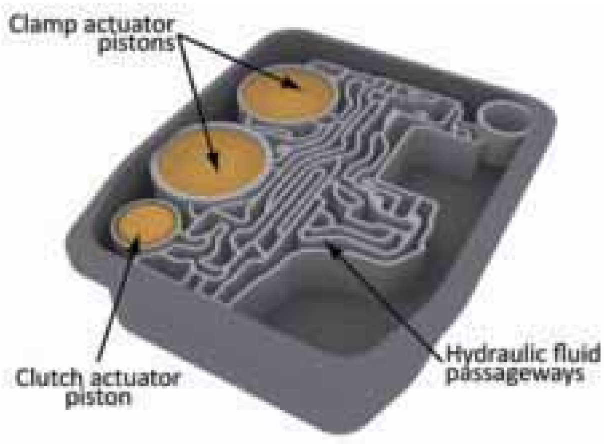


Figure 4.5
The valve body is the hydraulic control center of the automatic transmission.

Seals

Transmission seals and gaskets prevent transmission fluid from leaking out of the system. The automatic transmission has two main seals, the front and rear seal. The front seal allows fluid to travel between the torque converter and transmission; the rear seal prevents fluid from leaking past the output shaft. Other seals maintain internal pressure and provide for proper functionality of the hydraulic system.

Transmission operation can be significantly compromised if seals become brittle and dry. Seals that do not function as designed compromise transmission operation and can lead to failure.

Lubrication Requirements

Compatibility with elastomer seal materials is necessary to ensure proper operation. The lubricant prevents elastomeric seal materials from drying out or becoming impaired by degradation. Transmission fluids condition seals so they maintain strength and functionality for optimal hydraulic performance and longevity.

In addition to fluid compatibility issues, seal materials degrade from heat and chemical by-products produced during operation. A fluid that controls thermal degradation and acid buildup ultimately helps preserve the integrity of hydraulic seals.

CVT – Constant Velocity Transmissions (Continuously Variable Transmission)

Constant velocity transmissions do not rely on gears to change gear ratios. Instead, they use a belt and pulley system to generate continuous ratio changes that provide a more efficient and smooth transition between speed and torque changes.

Operation

The pulley system is the most common CVT configuration. Friction between the CVT belt and pulley is a key element to how the CVT operates. An input pulley, rather than a gear, is used to power the belt that drives the output pulley, which transfers power to the driveshaft. If the frictional interaction between the belt and pulleys is insufficient, performance declines.

Gear ratios are achieved by the variable-diameter pulleys that change position relative to one another. CVTs can generate virtually infinite gear ratios because the pulley can move in small increments to generate small gear ratio changes. The farther apart the pulleys are from each other, the lower the gear ratio; pulleys set close together achieve higher gear ratios.

Early CVT systems were plagued by frequent belt failures, but improvements to belt materials have made the modern CVT a reliable and efficient system.

Lubrication Requirements

Transmission fluid for CVTs protects against wear and scuffing while maximizing the frictional interaction between the components. CVT fluids require precise frictional properties to supply sufficient torque transfer

Figure 4.6
Dual-clutch transmission
Used with kind permission from ZF Friedrichshafen AG

between the pulleys. The fluid must provide enough lubricity to adequately lubricate and maintain a full-fluid film, but it can not be so slippery that it inhibits torque transfer.

DCT – Dual-Clutch Transmissions

The dual-clutch transmission is an intermediary between an automatic and manual transmission. It has two gearboxes and two clutches. Each gearbox is used for either the even (2, 4 and 6) or odd (1, 3, 5 and reverse) set of gears. The second clutch is used to maintain power to the wheels during gear changes. The inclusion of a second clutch provides smooth shift qualities that minimize the duration of gear changes.

Operation

Current dual-clutch transmissions use multi-plate clutches to transfer torque from the engine. Wet clutches are mainly used in high-torque applications that require greater heat dissipation. Dry clutches are typically used in low-torque applications.

DCT OEMs claim fuel efficiency gains of as much as 20 percent over step-type automatic transmissions because they do not have the associated idle time during gear changes.

Lubrication Requirements

The DCT lubricant must have precisely controlled frictional properties to accurately operate the dual clutches. Viscosity stability is required to provide predictable clutch performance in temperature extremes.

Step-Type Automatic Transmission

The step-type automatic transmission is most common in modern vehicles and uses planetary gears to achieve gear ratios required for different driving conditions.

The gears in the planetary gear train are constantly mated. Hydraulic pressure controls brake bands and clutch packs that engage and disengage the gears as needed. The fluid must have good hydraulic properties to support optimal operation of these components.

Oil cleanliness is important for optimal operation. Fluid contaminated by sludge and varnish can inhibit fluid movement through the valve body's narrow passages, which will impair transmission operation. Fluid suffering from excessive contamination can result in sluggish operation and fluid starvation. A loss of gears can occur, including possible transmission failure.

AMSOIL Advantage

Frictional Properties and Anti-Shudder Performance

AMSOIL Multi-Vehicle ATF is fully fortified with friction modifiers engineered to deliver outstanding clutch-holding capacity, torque-transfer and anti-shudder performance over the life of the fluid.

The coefficient of friction (how two surfaces behave relative to their movement against one another) is a major factor in shift quality, and fluids can be formulated to exhibit 'grabby' or 'slippery' characteristics, determined by the friction modifiers used in the formulation.

Different transmission materials require different frictional properties. If friction modifiers break down in the fluid, shift quality will become hard and erratic. AMSOIL fluids resist friction modifier breakdown by using high-quality base oils in tandem with robust friction modifiers. Their ability to maintain precise friction performance over the life of the fluid allows clutches to operate smoothly with no harsh or erratic shifting.

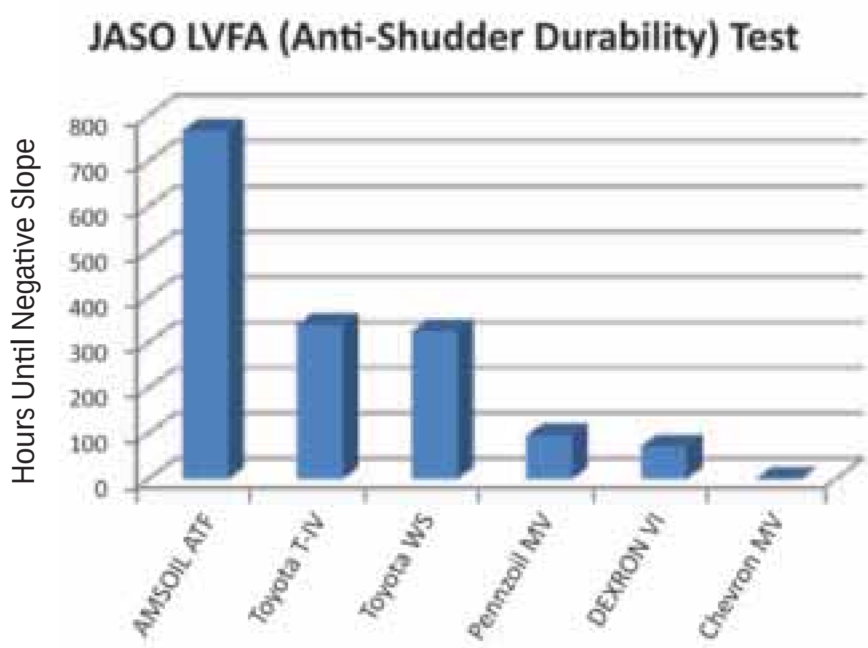


Figure 4.7
AMSOIL Multi-Vehicle ATF displays outstanding friction control properties, with anti-shudder capabilities beyond 700 hours of continuous testing. (August 2009)

The JASO LVFA/Anti-Shudder Durability Test

The Japanese Automotive Standards Organization (JASO) requires a Low Viscosity Friction Durability (LVFD) or Anti-Shudder Durability (ASD) test to qualify transmission fluids for use in sensitive Asian transmissions such as those in Toyota and Nissan applications.

AMSOIL Advantage

The results of the JASO LVFA test determine the duration for which transmission fluids maintain the positive friction-to-speed relationship that reduces torque converter clutch shudder.

Figure 4.7 shows AMSOIL Multi-Vehicle ATF outperformed major OEM and service brands, maintaining the friction performance necessary for anti-shudder performance for 768 hours. The next closest OEM brand was Toyota T-IV, maintaining a positive friction-to-speed relationship for 340 hours, 428 hours less than AMSOIL Multi-Vehicle ATF.

Heat/Oxidation Resistance

All lubricants oxidize when exposed to increasing temperature; the higher the temperature the faster the oxidation rate. Oxidized oil thickens and loses lubricity, requiring more energy and increasing overall fuel consumption. Oxidized oil will also produce harmful acids that can lead to corrosion and the formation of sludge and varnish.

AMSOIL base oils are engineered with fully saturated synthetic molecules, which makes them naturally resistant to oxidation. Fully saturated molecules have a sealed molecular structure with few openings for other molecules, such as oxygen molecules, to attach. The fully saturated structure of AMSOIL fluids resists thickening from thermal and oxidation reactions. In addition to their natural oxidation resistance, AMSOIL lubricants are fortified with antioxidants that help further extend fluid life.

Powerful dispersants in AMSOIL automatic transmission fluids prevent sludge and varnish deposits from agglomerating into larger, damaging particles that clog valve body passages and can harm the transmission and cause failure.

AMSOIL automatic transmission fluids have exceptional high-temperature performance and oxidation resistance, providing significantly increased fluid life expectancy over conventional transmission fluids.

The Aluminum Beaker Oxidation Test (ABOT)

The MERCON V Aluminum Beaker Oxidation Test (ABOT) is a 300-hour oxidation test in which a gear pump circulates and shears the test fluid in an aluminum beaker. Fluid temperature is maintained at 311°F (155°C), and samples are drawn and analyzed at intervals throughout the test. To evaluate the fluid's tendency to attack metal materials, metal catalysts commonly found in transmission systems are also submerged in the test fluid. Figure 4.8 shows how AMSOIL Multi-Vehicle ATF stands up to the MERCON V viscosity-increase specifications.

In order for a fluid to pass the current MERCON V specifications, it must not exceed a 25 percent viscosity increase following the 300 hour test. AMSOIL Multi-Vehicle ATF has an initial 34.4 cSt viscosity. In order to pass the MERCON V specification, it can't exceed 43 cSt upon completion of the 300-hour oxidation test.

Figure 4.8 shows that AMSOIL Multi-Vehicle ATF easily passed the MERCON V benchmark with a minimal increase of 3.2 percent. It's final viscosity after the test was 35.5 cSt, well below the MERCON V 25 percent viscosity-increase limit. AMSOIL Multi-Vehicle ATF is able to maintain viscosity under extreme oxidative conditions.

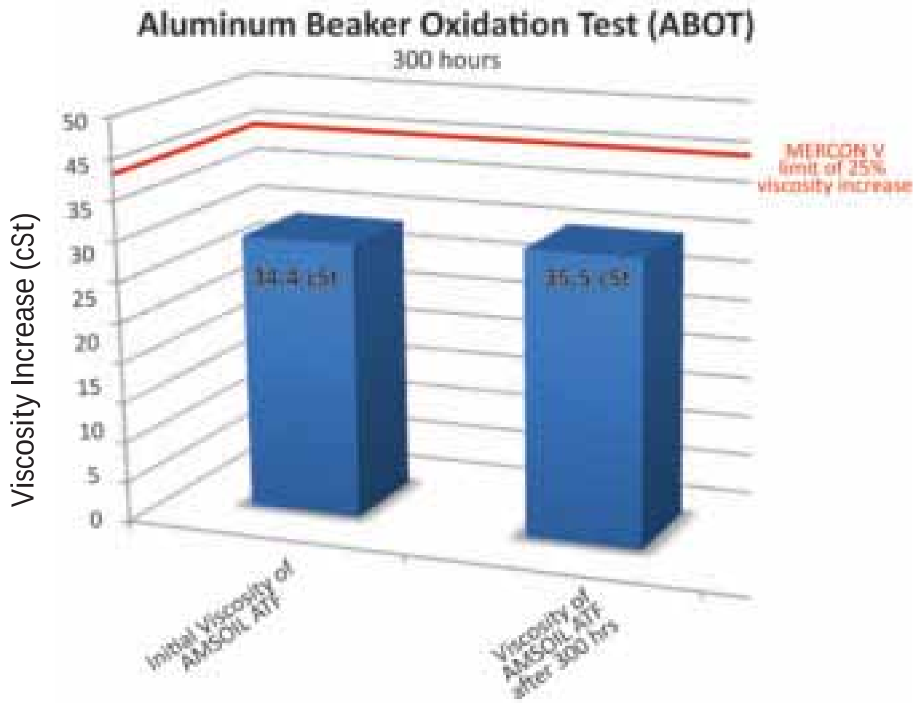


Figure 4.8
AMSOIL displays minimal viscosity increase after the Aluminum Beaker Oxidation Test (ABOT) and meets MERCON V specification requirements for this test. (August 2009)

Figure 4.9
AMSOIL Multi-Vehicle ATF developed virtually no sludge and varnish during the Aluminum Beaker Oxidation Test (left), while the competitive oil demonstrates significant sludge and varnish (right).

Sludge and varnish develop when oxidized by-products from the oil agglomerate. The absence of sludge and varnish formation during the 300-hour ABOT Test, shown in Figure 4.9, demonstrate AMSOIL Multi-Vehicle ATF was able to inhibit oxidation reactions, maintaining its ability to provide clean and efficient transmission operation.

AMSOIL Advantage

Shear Stability and Wear Protection

The uniform molecular structure of AMSOIL synthetic automatic transmission fluids contributes to their outstanding film strength and shear performance and allows them to maintain a protective fluid barrier during aggressive operation. While poor-performing, conventional fluids rupture under the pressure, AMSOIL automatic transmission fluids are fortified with anti-wear and extreme-pressure additives that provide a sacrificial layer of protection. Conventional oils do not have the advantage of a uniform molecular structure and lose viscosity under normal conditions. Synthetics have inherent molecular strength and provide superior protection against shear forces.

Gear Durability Test

The Gear Durability Test determines a transmission fluid's ability to prevent planetary gear wear under conditions of high temperature and high load. The test simulates conditions of severe uphill driving, towing, extreme high temperatures and high torque.

It is completed in two rigorous phases on a major OEM four-speed automatic transmission. The first phase subjects the transmission to constant running speeds in second gear under high-torque conditions. The second phase subjects the same transmission to a constant speed while doubling the amount of torque from the first phase.

At the conclusion of the test, the transmission is disassembled and the planetary gear set is examined. Successful fluids support the transmission for the entire duration of the test with minimal tooth pitting and gear fracture.

Figure 4.10 shows that AMSOIL Multi-Vehicle ATF passed the Gear Durability Test with very little pitting and no tooth fracture. Competitive ATF Fluids A and B did not fare as well, with major pitting to transmission gears.

Figure 4.10
AMSOIL Multi-Vehicle ATF (far right) passes the Gear Durability Test. (August 2009)

KRL Shear Stability Test

A gear lubricant's shear stability is measured by the KRL Shear Stability Test. This mandatory test qualifies gear oils under the SAE J-306 standard. In the KRL Shear Stability Test, fluid is tested at 212°F (100°C) with a tapered-roller bearing under a 5,000 lb. load, spinning at 1,475 rpm. After 40 hours of rigorous testing, fluid viscosity loss is measured.

Figure 4.11 shows that AMSOIL Multi-Vehicle ATF performed better than the fluids compared in this study.

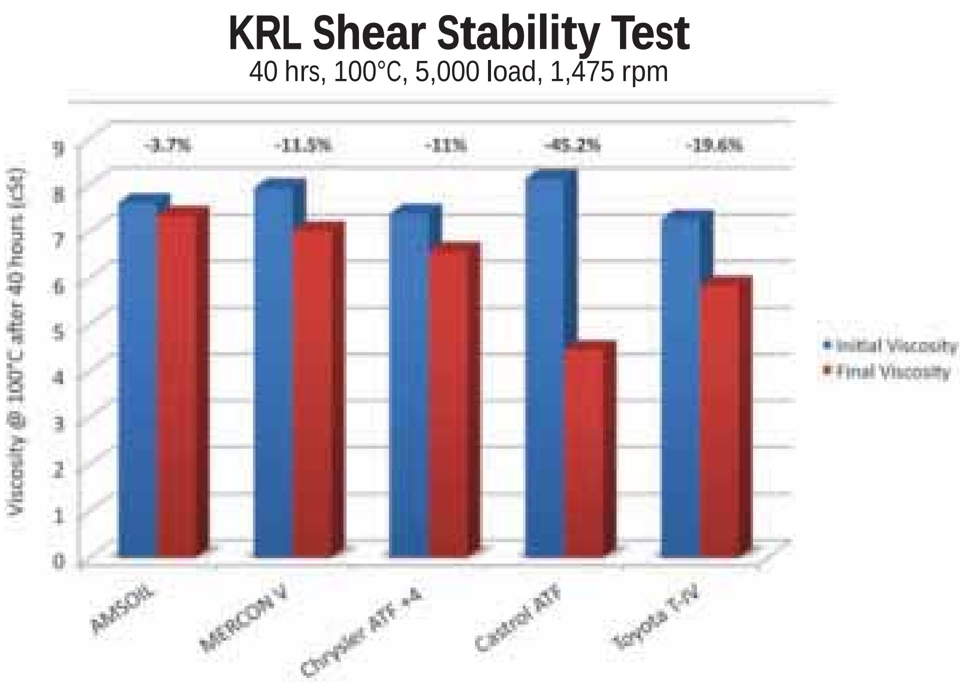


Figure 4.11
AMSOIL Multi-Vehicle ATF demonstrates excellent initial viscosity and viscosity retention in the Shear Stability Test. (August 2009)

Cold-Temperature Properties

Cold temperatures increase the viscosity of transmission fluid, which can result in fuel economy loss. Transmission operation can also suffer, from sluggish response to reduced shifting capacity.

AMSOIL Multi-Vehicle ATF provides outstanding cold-temperature performance and provides fluidity down to -53°F (-47˚C). The wax-free, uniform molecular structure of AMSOIL synthetic automatic transmission fluids provides responsive shift times and improved fuel efficiency in cold temperatures.

AMSOIL Multi-Vehicle ATF exceeds the cold-temperature performance benchmarks with a viscosity of 1,295 cP at -4°F (-20°C) and 9,800 cP at -40°F (-40°C), significantly below the maximum limit for MERCON V fluids, which are 1,500 cP and 13,000 cP respectively.

AMSOIL Multi-Vehicle ATF helps eliminate viscometric drag during extreme cold temperatures, which improves mechanical efficiency, fuel economy and wear protection.

AMSOIL Advantage

AMSOIL ATF provides outstanding cold-temperature performance compared to major OEM transmission fluids and service brands. It resists excessive thickening at -40°F (-40°C), significantly better than the fluids compared in Figure 4.12. Note that Castrol ATF exceeds the limits for all three fluids.

Brookfield Viscosity
at -40°C (-40°F)

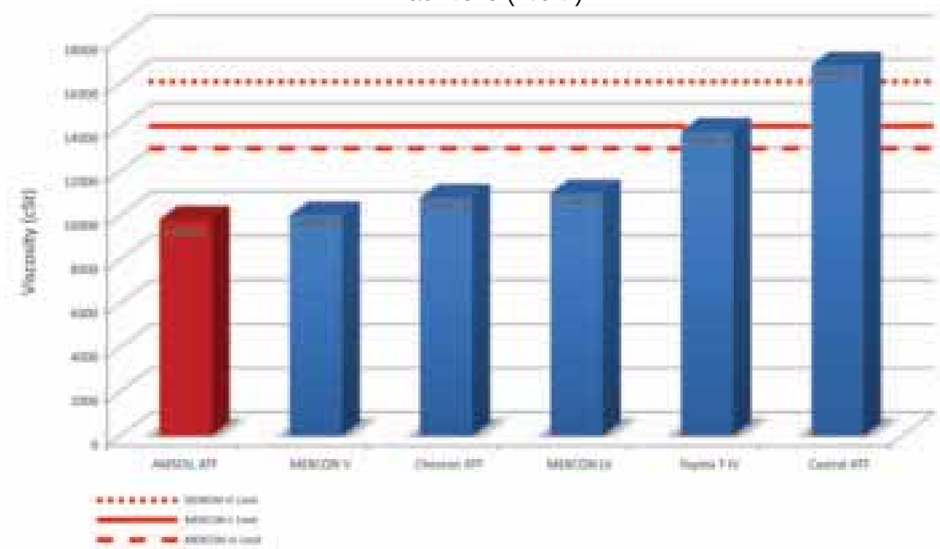


Figure 4.12
AMSOIL Multi-Vehicle ATF exceeds the cold-temperature performance of many OEM and service brands, as well as meets the viscosity limits for major specifications such as MERCON V, MERCON LV and DEXRON VI. (August 2009)

Foaming

The gears, bearings and clutches in automatic transmissions churn oil and air together during operation, which can cause foam development.

Foam harms the operation and longevity of transmission components because it can significantly reduce critical fluid-film barriers. Foam in transmission oil can cause erratic shifting and starve the transmission of fluid, both of which can cause transmission damage or failure.

AMSOIL ATF is formulated with anti-foam additives designed to rapidly reduce the surface tension of foam bubbles that develop. These additives ensure that foam rapidly collapses, minimizing the risk of entrained air and maintaining a protective fluid barrier between components.

Foaming Tendency Testing (ASTM D-892)

The Foaming Tendency Test (ASTM D-892) evaluates a lubricating fluid's tendency to foam. Air is blown through the test fluid at a specific temperature, and the volume of foam that remains after a 10-minute settling period is measured. The test is conducted in a number of sequences to simulate the start-stop operating conditions common for automatic transmission fluids.

AMSOIL Advantage

Figure 4.13 shows AMSOIL Multi-Vehicle ATF outperforms the MERCON V benchmark for foaming tendency per the Foaming Tendency Test.

Foaming Tendency Limits
MERCON V Specification

	MERCON V Limits	AMSOIL
Sequence I	50/0	0/0
Sequence II	50/0	15/0
Sequence III	50/0	0/0

Figure 4.13
AMSOIL Multi-Vehicle ATF surpasses the MERCON V specification for foaming tendency. (August 2009)

Section Review

1. How is an automatic transmission distinguished from a manual transmission?

   ____

   ____

2. Who sets the specific lubrication requirements for transmissions?

   ____

   ____

3. What drives fluid specification changes?

   ____

   ____

4. What do changes to fluid specifications usually mean in terms of fluid performance?

   ____

   ____

5. What is the fundamental reason that one transmission fluid cannot be used in all transmissions?

   ____

   ____

6. Automatic transmission fluid must have good_______________ abilities to prevent solid contaminants from collecting into larger, channel-clogging particles.

7. When the friction modifiers break down in the fluid, shifting can become ________________.

8. The saturated molecular structure of the synthetic fluids acts as an ________________, suppressing oxidation and oxidized by-products.

9. List two benefits of an automatic transmission fluid with excellent cold-temperature properties.

   ____

   ____

Section 4

Mobile Drivetrain Fluids: Section 5
Heavy-Duty Trucks and Equipment

Introduction

Section 5 provides a technical introduction to the operation and fluid requirements of powershift, hydrostatic and heavy-duty transmissions.

Section Objectives

After studying Section 5, you should understand and be able to explain the following terms and concepts:

1. Importance of fluid friction properties
2. Fluid viscosity requirements based on temperature
3. Application demand differences between manual and automatic transmissions
4. Benefits of automated shifting
5. Hydrostatic transmission applications and benefits
6. Powershift transmission shifting characteristics
7. Friction requirements for powershift transmissions

Section Keywords

The following keywords are explained in this section. Pay particular attention to their explanations as these concepts will serve as building blocks for future lessons.

Clutch Glazing

Manual vs. Automatic Heavy-Duty Transmissions

The choice between an automatic versus a manual heavy-duty transmission is one driven by utility. Manual heavy-duty transmissions are typically used for long-haul applications where fuel efficiency at high speeds and low-torque conditions is required. Manual heavy-duty transmissions are preferred in these applications because they provide improved fuel efficiency during high-speed operation. These applications require fluids with controlled frictional properties to provide wear protection at all possible operating temperatures.

Automatic heavy-duty transmissions are suited for applications that require frequent stopping and starting, such as fleet services like school buses and public transit vehicles. They are also preferred in frequent stop-and-start applications where high torque during acceleration is required, like garbage trucks and utility vehicles.

Manual Heavy-Duty Transmissions

Manual heavy-duty transmissions are found in off-road equipment such as dozers, backhoe loaders, cranes, railway and mining equipment, road graders and commercial boats. They are also used in long-haul over-the-road applications.

They are designed with standard manual transmission configurations with a shift lever and clutch. In the modern over-the-road market, the automated manual transmission is becoming increasingly popular and provides shifting ease and maximized fuel economy over standard manual transmissions.

In general, both standard and automated heavy-duty transmissions are mechanically similar to those found in consumer applications. The fundamental differences are the torque and load capacities and how automated versions are controlled. Automated manual transmissions have a three-button control station to select forward, reverse and neutral gears.

Automated heavy-duty manual transmissions, such as the Eaton Fuller UltraShift™, use electronic controls and actuators to select the most efficient gear for current driving conditions. It also incorporates fully automated shifting for starting and stopping and has no clutch pedal.

Frictional Properties

The proper operation of powershift and heavy-duty transmissions is dependent on the frictional qualities and durability of the lubricating fluid.

Powershift clutches rely on the frictional properties of the fluid for smooth and dependable operation. AMSOIL fluids, like Torque-Drive® (ATD), have inherent oxidative stability to provide extra protection against oxidation and improved shift quality.

AMSOIL CT Series

AMSOIL Synthetic Powershift Transmission Fluid comes in SAE 50 (CTL), SAE 30 (CTJ) and SAE 10W (CTG) viscosity grades. It is specifically engineered for use in heavy-duty powershift transmissions, wet brakes and final drives. AMSOIL SAE 50 Synthetic Powershift Transmission Fluid can be used in heavy-duty manual transmissions. It is formulated with top-quality synthetic base stocks and carefully balanced additives specific to provide extended drain intervals in heavy-duty applications.

AMSOIL Synthetic Powershift Transmission Fluid has frictional characteristics that are compatible with metallic and non-metallic friction materials, such as those used in synchronizer units. Its enhanced stability reduces excessive brake noise and vibration. Durable friction properties help eliminate clutch slippage and provide efficient clutch operation that reduces thermal deposits and inhibits clutch glazing.

AMSOIL Synthetic Powershift Transmission Fluid is shear stable and provides excellent wear protection in conditions of sustained pressure, high horsepower and high torque.

AMSOIL Advantage

- Thermal and oxidation stability improves reliability and performance
- Shear stable under high thermal and load conditions
- Durable friction control supports friction surfaces and shift quality
- Provides instant shift response
- Functions in extreme conditions of heat and cold
- Protects from copper corrosion and rust
- Inhibits foam to reduce harmful metal-on-metal contact

Automatic Heavy-Duty Transmissions

Fluid quality and performance is extremely important for both on- and off-highway automatic transmission applications. These transmissions are commonly found in transit buses, motor coaches, garbage haulers, school buses, dump trucks, utility vehicles, tow trucks and line-haul trucks.

Automatic heavy-duty transmissions are similar to those in consumer applications; however, these larger versions have more gears and larger valve bodies with demanding fluid requirements.

Heavy-duty automatic transmission torque converters can achieve power densities that simulate the first three gears in heavy-duty manual transmissions. They require shear-stable fluids with high film strength for protection under maximum load. These transmissions use electronic controls that sense operating conditions and optimize gear selection for improved fuel economy.

Oxidative stability is required to protect the system under frequent starting and stopping conditions under heavy load.

Torque-Drive Synthetic Automatic Transmission Fluid

AMSOIL Torque-Drive® Synthetic Automatic Transmission Fluid (ATD) provides superior performance for heavy-duty automatic transmission applications. It is engineered to resist oxidative degradation and sludge and varnish buildup. Torque-Drive is naturally resistant to the harmful effects of heat and helps to preserve frictional properties for durable performance.

Many heavy-duty transmission fluids include viscosity index improvers to stabilize the fluid's viscosity over a wide range of temperatures. AMSOIL Torque-Drive Synthetic Automatic Transmission Fluid has inherent viscosity stability due to its synthetic structure, eliminating the need for VI improvers that shear down in extreme conditions.

AMSOIL Advantage

- Thermal and oxidation stability improves reliability and performance
- Shear stable under high thermal and load conditions
- Durable friction control supports friction surfaces and shift quality
- Provides instant shift response
- Functions in extreme conditions of heat and cold

Tractor Fluids and Hydrostatic Transmissions

Hydrostatic equipment relies on hydraulic fluid to create motion and power. Applications commonly driven by hydraulics include those found in agricultural and commercial applications.

The main components of the hydrostatic transmission include a pump to pressurize hydraulic fluid, a motor to control the final mechanical power of the machine, hoses to carry the hydraulic fluid and an engine that powers the hydraulic pump.

Hydrostatic transmissions can be powered over a wide range of torque-to-speed ratios and can move heavy loads with no loss of power. Hydraulic fluid is used as the power transfer medium because it provides predictable power capabilities regardless of operating temperatures. Hydraulic fluid also provides instant inertia, which is the ability to provide instantaneous power from a resting state. Typical manual and automatic transmissions have to overcome some inertia from a stopped or idling position.

Hydrostatic transmissions convert the engine's mechanical power into fluid power. Unlike components in a manual or automatic transmission, the parts in a hydrostatic transmission are easier to maintain and replace.

Hydrostatic transmissions are common in farm and tractor equipment, forklift trucks, pavement rollers, ditchers, concrete formers and a variety of off-road equipment. Well-known hydrostatic applications include Briggs & Stratton and Kohler transmissions found in consumer-tractor equipment.

AMSOIL Synthetic Tractor Hydraulic/Transmission Oil (ATH)

AMSOIL Synthetic Tractor Hydraulic/Transmission Oil (ATH) is an all-weather Universal Tractor Transmission Oil (UTTO) engineered to meet the tough demands of heavy-duty, hydraulic-powered farm and commercial equipment. Its unique and robust formulation effectively reduces wear, resists heat, protects against rust and extends fluid and equipment service life.

AMSOIL Synthetic Tractor Hydraulic/Transmission Oil provides excellent performance in extreme temperatures. It resists thinning at high temperatures and thickening at low temperatures; ATH provides fluidity down to -51°F (-46°C). AMSOIL Synthetic Tractor Hydraulic/Transmission Oil eliminates the need for seasonal oil changes and exceeds the most demanding all-weather specifications for both Case New Holland 3525 and 3526 (formerly Ford New Holland FNHA-2-C-200 & 2-C-201) and John Deere J20C & J20D specifications.

AMSOIL Synthetic Tractor Hydraulic/Transmission Oil is formulated with durable friction modifiers that suppress wet-brake chatter and provide continuous friction stability for long-term wet-brake operation.

AMSOIL Advantage

- Excellent extreme-temperature performance
- Stable friction control provides smooth operation and inhibits brake chatter
- Foam control for smooth operation
- Advanced friction properties for instant shift response
- Oxidation resistance extends lubricant and equipment life
- Seal and hose conditioners maintain hydraulic system components
- Wear protection under all load conditions
- All-temperature performance eliminates the need for seasonal oil changes

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Powershift Transmissions

Heavy-duty commercial applications operate in a wide range of conditions and have a unique set of transmission fluid requirements. Applications like dozing, ripping, side cutting and skidding logs are a few examples where the application has the unique need to go from forward to reverse instantaneously.

Powershift transmissions provide the ability to shift rapidly and frequently without a loss of drive power. The operator is able to put the equipment in forward or reverse gear with immediate response. Powershift transmissions use a number of friction surfaces to achieve these rapid maneuvers. Modern powershift transmissions require a dedicated fluid engineered with specific, controlled frictional properties not found in other products.

Powershift Transmission Fluid

Powershift fluids perform as a general lubricant to protect components like gears, bearings and clutches; however, powershift fluids must also eliminate slippage during heavy-duty, high-torque operation. Powershift fluids must provide instantaneous friction to clutch plates so power transfer between friction surfaces is maximized.

Powershift fluids engineered with precise frictional properties help maximize the shift time between materials, allowing the equipment to operate efficiently and with control. Rapid shifts reduce clutch plate slippage and help limit friction and heat generated between the two surfaces. Rapid shifts and efficient friction transfer maximizes equipment productivity.

Powershift fluids with inadequate frictional characteristics can lead to oxidation by-products depositing on friction surfaces. These deposits cause plates to lose porosity and inhibit complete clutch engagement, which generates excessive heat. The process, referred to as *clutch glazing*, compounds as more oxidation and by-products deposit on clutch surfaces and more heat is generated and retained. Clutch glazing ultimately leads to clutch failure.

Fluids with inadequate frictional characteristics cause clutch materials to slip against each other. Friction surfaces deteriorate from excessive friction and heat when they slip against each other. When this happens, friction material becomes suspended in the fluid and is circulated in the system, which damages component surfaces. Clutch debris can clog the small orifices in solenoid-actuated transmissions and restrict or impede the flow of fluid.

Synthetic Powershift Transmission Fluids (CTJ/CTG/CTL)

AMSOIL Synthetic Powershift Transmission Fluid is designed specifically for heavy-duty powershift transmissions that operate under high-torque conditions. It is engineered with top-quality synthetic base stocks and additives that provide maximized performance during extended drain intervals.

AMSOIL Synthetic Powershift Transmission Fluid is compatible with metallic and non-metallic friction materials. Precise frictional characteristics help eliminate excessive brake noise, vibration and clutch glazing.

AMSOIL Advantage

- Durable holding capacity for high-torque outputs
- Thermal and oxidation stability to reduce deposits and clutch glazing
- Compatible with a wide range of friction materials
- Advanced friction properties provide instant shift response
- Reduces wear in pumps, brakes and transmissions
- Robust formulations double equipment up-time

Section 5

Section Review

1. What property of the oil affects shift quality?

2. Give one reason why a heavy-duty automatic transmission might be chosen over a manual transmission.

3. What type of transmission would be best-suited for long-haul, low-torque operation?

4. Describe why the hydrostatic transmission and fluid can be advantageous over other transmission styles.

5. What is a characteristically unique ability of the powershift transmission?

6. Why are frictional properties important to powershift transmission operation?

7. Describe clutch glazing and the mechanisms that cause it.

Appendix

Military MIL-PRF-2105E Performance Specifications for Lubricating Oil

Military MIL-PRF-2105E (1995)				
US Military Symbol	SAE Viscosity Grade	Kinematic (cSt) at 100°C min	Kinematic (cSt) at 100°C max	Brookfield Viscosity Max temp for 150,000 cP
GO-75	75W	4.1	--	-40
GO-80/90	80W-90	7.0	> 24	-26
GO-85-140	85W-140	11.0	> 41	-12

API Service Classifications for Gear Oil

API Automotive Service Classifcations for Gear Oil (July 1995)	
GL-1	• Manual transmission operating under mild conditions where petroleum or refined petroleum oils are suitable • Oxidation and rust inhibitors, defoamants, and pour dperessants may be added to improve the lubricant • Friction modifiers and EP additives cannot be used
GL-4	• Intended for axles with spiral bevel gears operating under moderate to severe conditions of speed or load • Axles with hypoid gears operating under moderate speeds and loads • Lubricants are acceptable in selected manual transmissions and transaxle applications where API MT-1 lubricants are unsuitable
GL-5	• Intended for gears, particularly hypoid gears in axles operating under various combinations of high-speed shock loads and low-speed, high-torque conditions • MIL-L-2105D lubricants satisfy this GL-5 specification (API classisfication does not require military approval)
MT-1	• Intended for non-synchronized manual transmissions used in buses and heavy-duty trucks • API MT-1 lubricants provide protection against the combination of thermal degradation, component wear, and oil seal deterioration that is not provided by lubricants meeting only the requirements of API GL-4 and API GL-5

SAE J-306 Automotive Gear Lubricant Viscosity Classification

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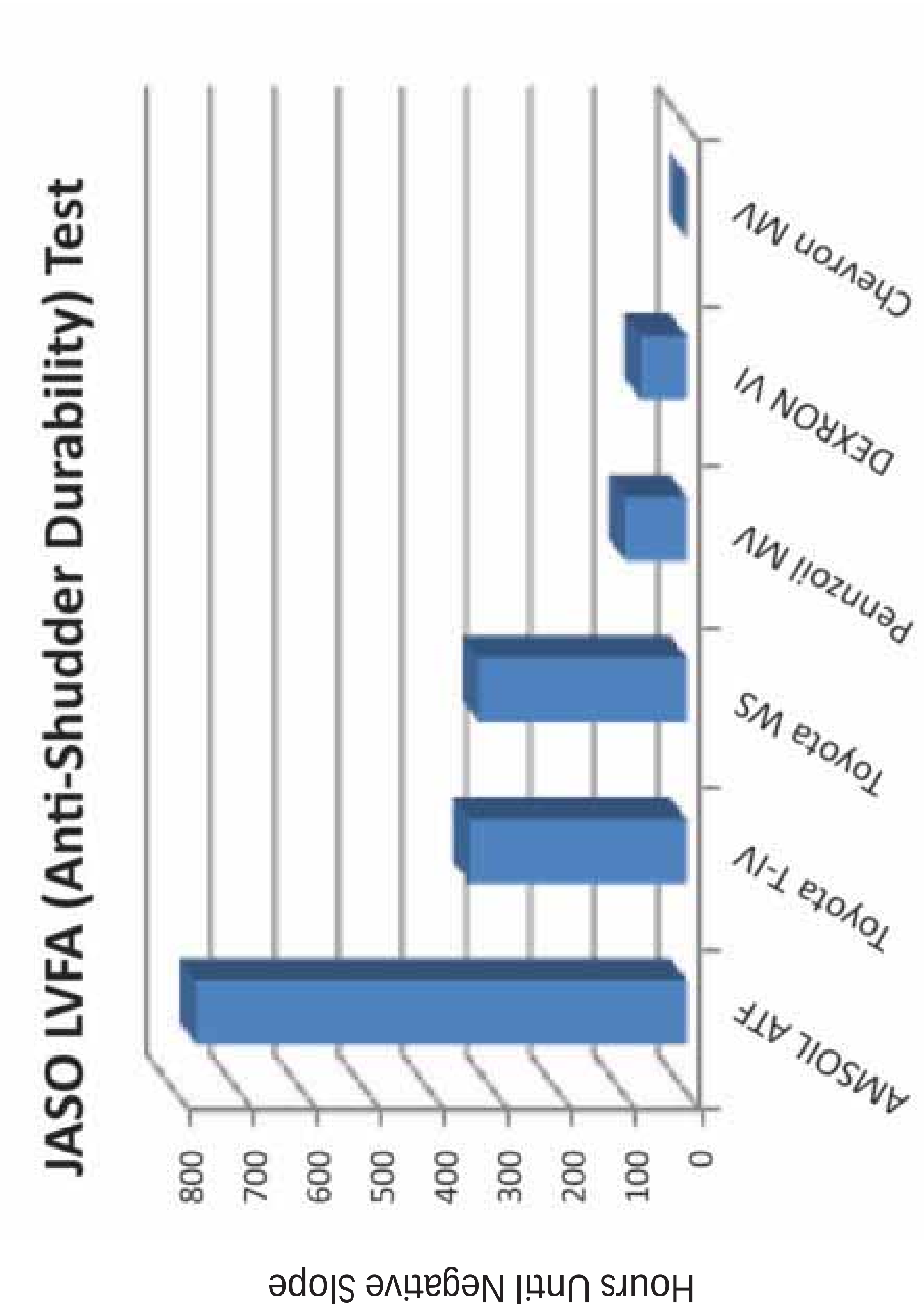
SAE J-306 Automotive Gear Lubricant Viscosity Classification

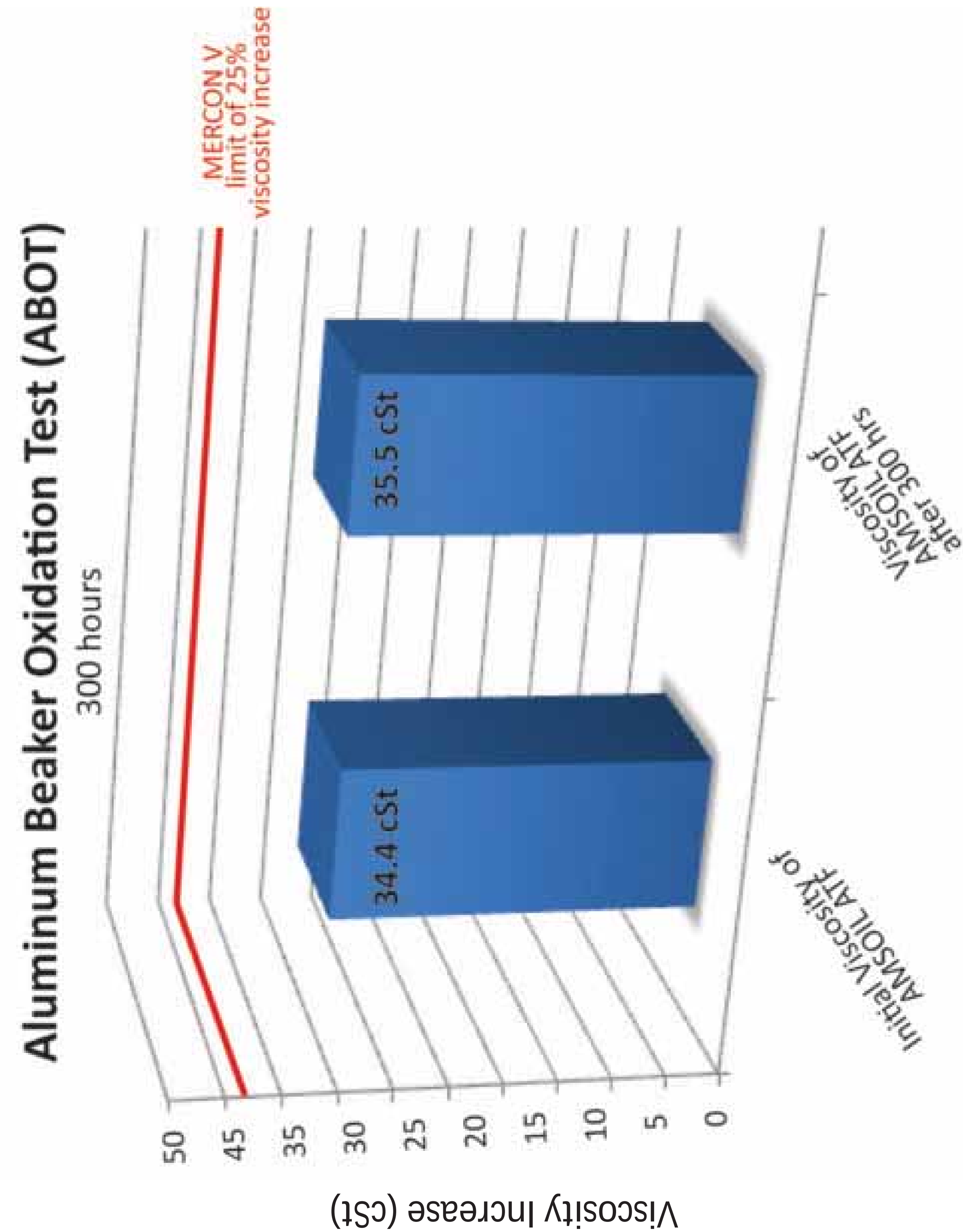
SAE Viscosity Grade	Maximum Temperature for Viscosity of 150,000 cP (°C) [1,2]	Kinematic Viscosity at 100°C (cSt) [3] Minimum [4]	Kinematic Viscosity at 100°C (cSt) [3] Maximum
70W	-55[5]	4.1	--
75W	-40	4.1	--
80W	-26	7.0	--
85W	-12	11.0	--
80	--	7.0	< 11.0
85	--	11.0	< 13.5
90	--	13.5	< 18.5
110	--	18.5	< 24.0
140	--	24.0	< 32.5
190	--	32.5	< 41.0
250	--	41.0	--

(1) Using ASTM D 2983
(2) Additional low-temperature viscosity requirements may be appropriate for fluids intended for use in light duty synchronized transmissions.
(3) Using ASTM D 445
(4) Limit must also be met after testing in CEC L-45-A-99, Method C (20 hours)
(5) The precision of ASTM D 2983 has not been established for determinations made at temperatures below -40°C. This fact should be taken into consideration in any producer-consumer relationship.

JASO LVFA (Anti-Shudder Durability) Test



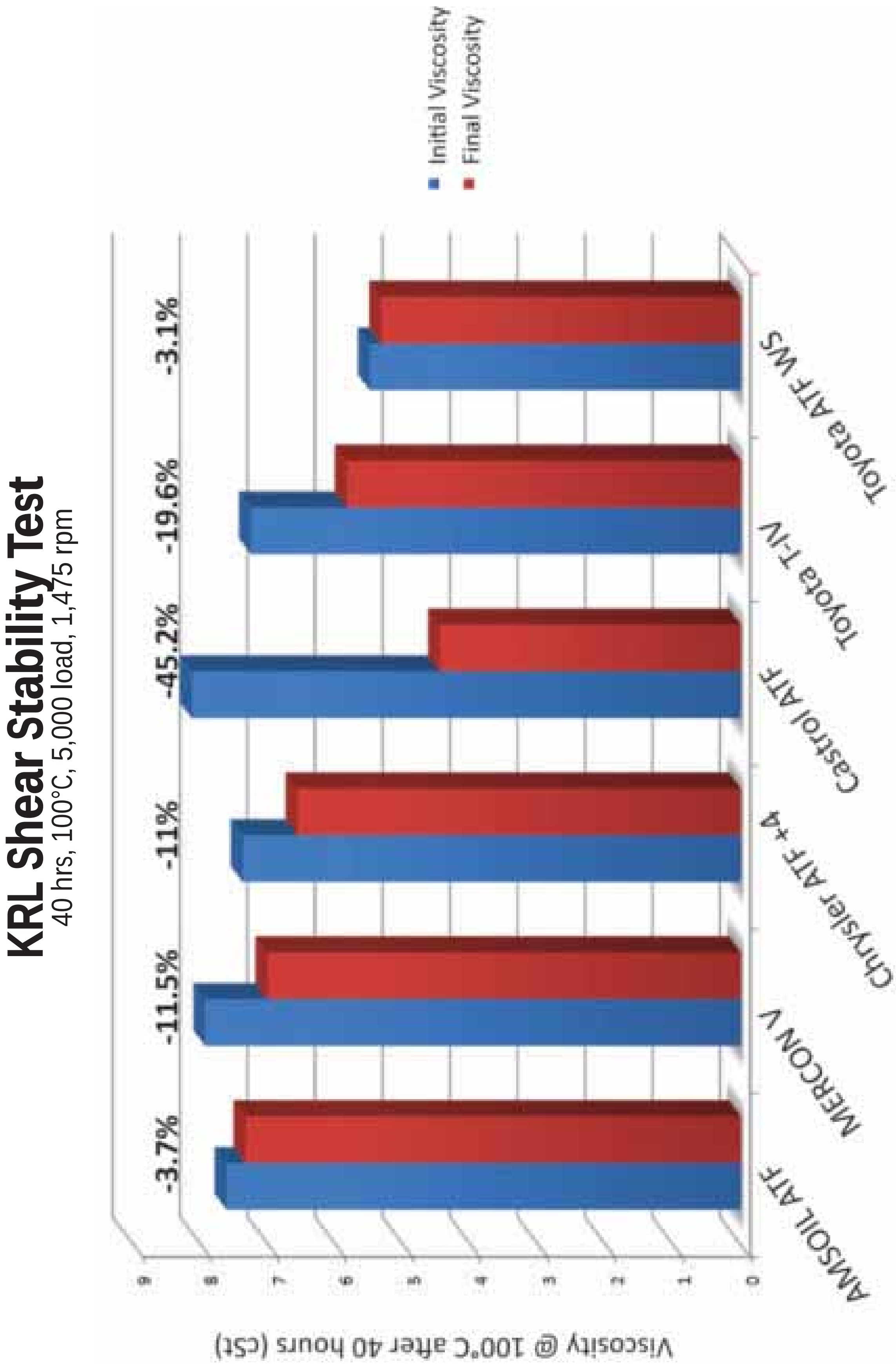
Aluminum Beaker Oxidation Test (ABOT)



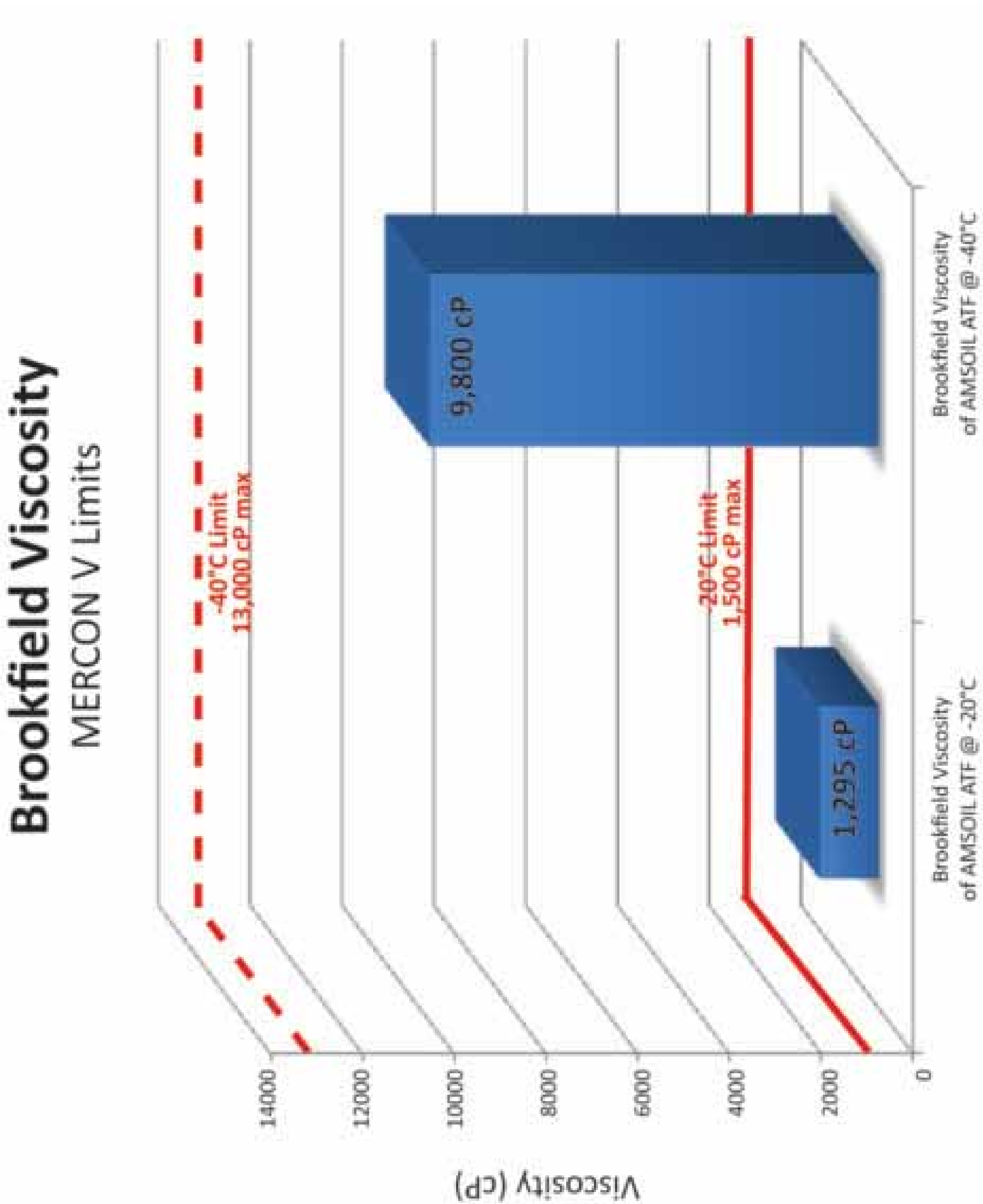
Gear Durability Test

Appendix

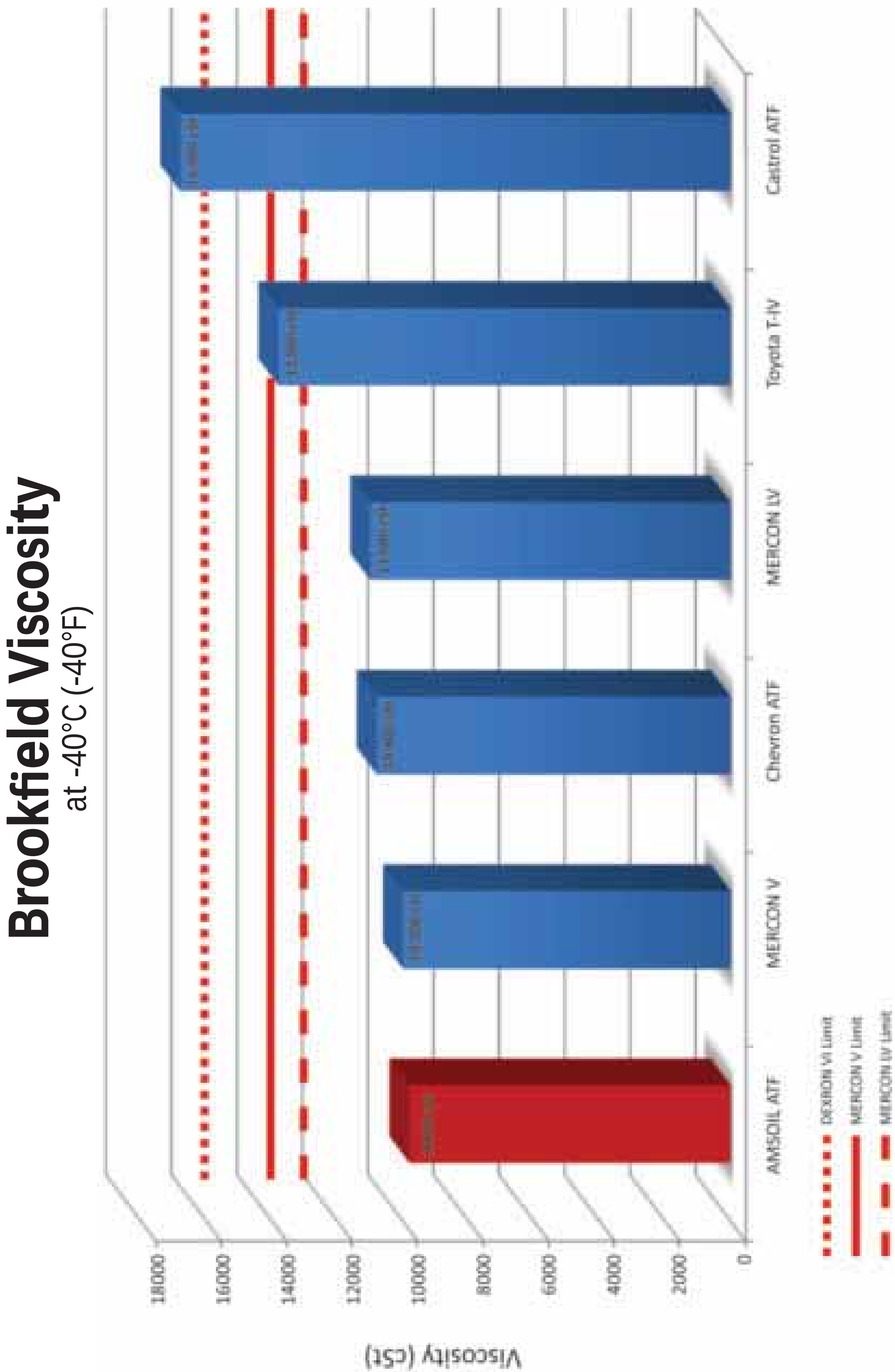
KRL Shear Stability Test



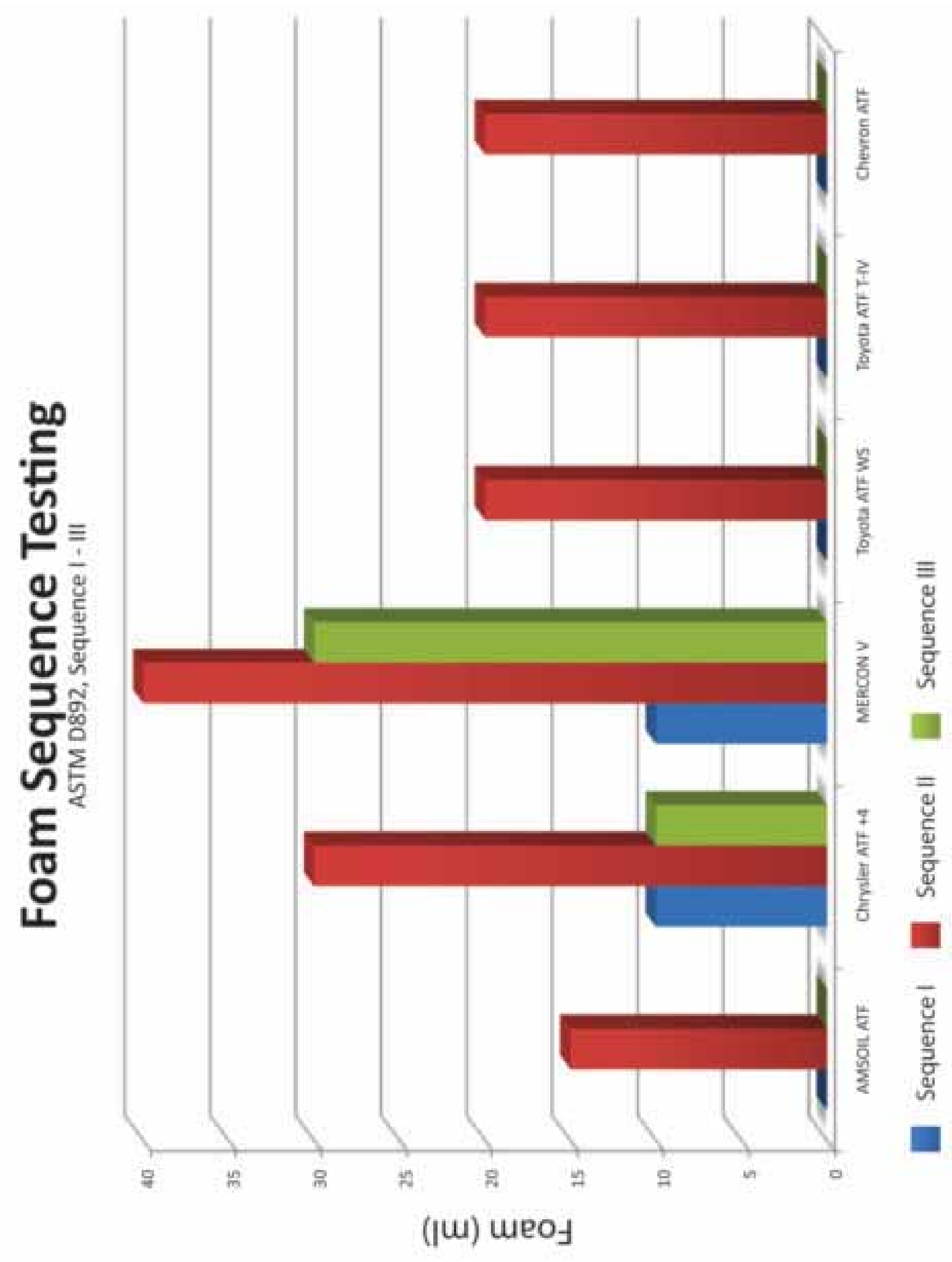
Brookfield Viscosity (MERCON V Limits)



Brookfield Viscosity Comparison



Foam Sequence Testing



Appendix

Foam Tendency Limits (MERCON V Specification)

Foaming Tendency Limits
MERCON V Specification

	MERCON V Limits	AMSOIL
Sequence I	50/0	0/0
Sequence II	50/0	15/0
Sequence III	50/0	0/0

Notes

Notes

AMSOIL®

The First in Synthetics®