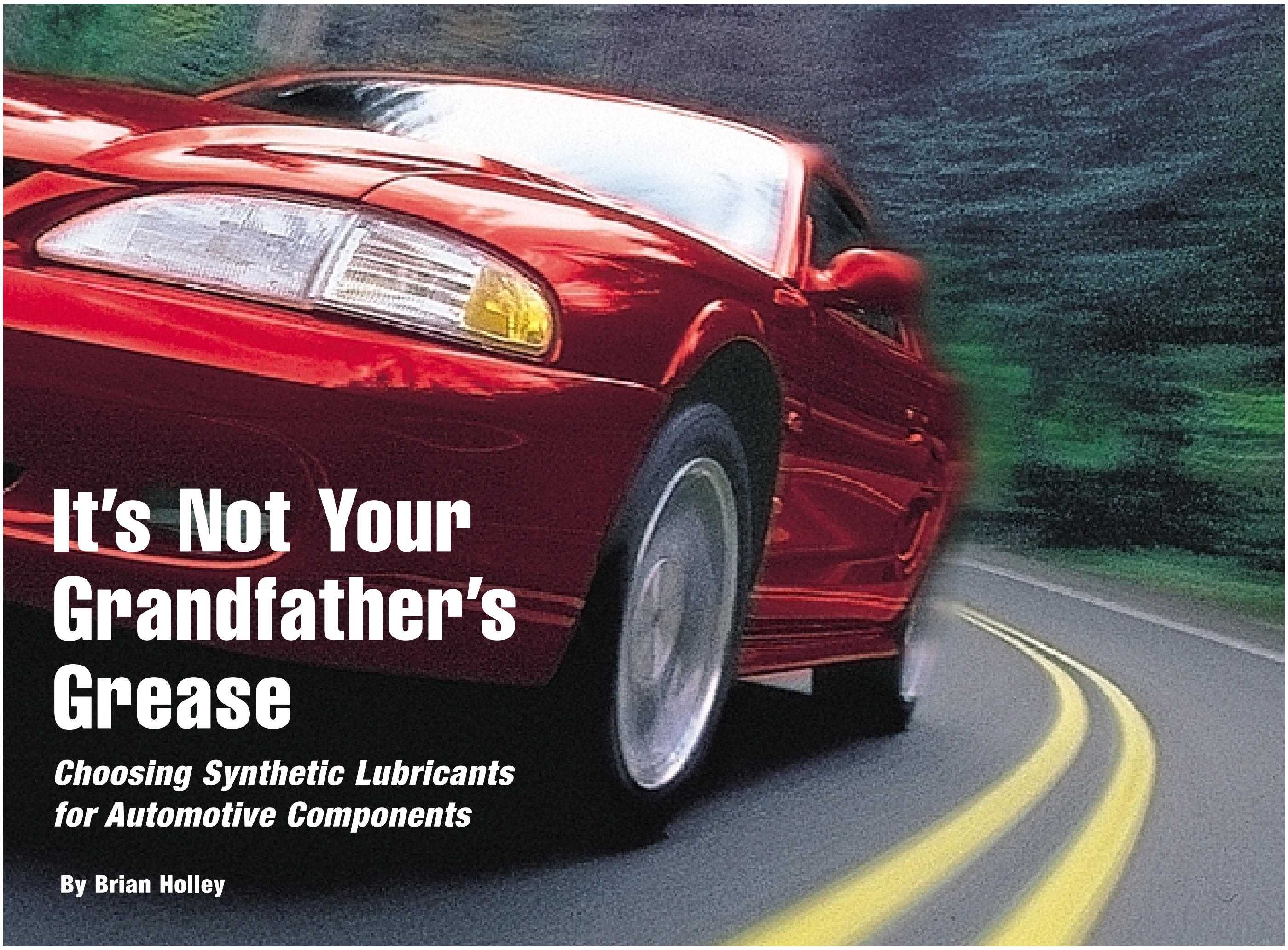


It's Not Your Grandfather's Grease

Choosing Synthetic Lubricants for Automotive Components

By Brian Holley

Tinkering under the hood is no longer part of the car owner's unwritten contract with automakers. Warranties and 100,000 mile tune-ups are. Automotive manufacturers have to make their components work harder and last longer than ever before — or fix them free of charge. At first, better metals, plastics, and rubbers were developed to extend the life of the product, but that wasn't enough. The petroleum-based lubricants, which maintain fluidity from about -20°C to 100°C, could not keep up with the broader temperature requirements. They'd bake or turn to sludge — and would hardly last the tens of thousands of cycles required to pass today's life tests. So in the early 1980s, automotive component engineers began to leave their grandfathers' greases behind and turn to synthetic lubricants to ensure performance and reliability.

Synthetic oils had been around for quite some time. Esters were developed in the 1940's and 1950's for the fast growing aviation industry, where lubricants for components in jets had to withstand freezing, high altitude temperatures — as well as the heat from jet engines. The next two decades widened temperature requirements even further in the aerospace industry, which gave rise to new classes of synthetics lubricants: polyphenylethers and perfluoropolyethers. Not counting non-commercial experimental synthetic oils, there are currently six basic families of synthetic lubricants: synthetic hydrocarbons, polyglycols, esters, silicones, fluoroethers, and polyphenylethers. Together, they extend the temperature capability of lubricants to -90°C on the cold end, to 250°C at the other end of the scale — a quantum improvement over what was once known as black gold!

Sensors were one of the first automotive components that required something better than petroleum grease. In the 1980s, throttle position sensors (TPS) and exhaust gas recirculating (EGR) sensors were introduced to monitor electronic fuel injection and exhaust emissions. These potentiometers, mounted on the air intake and exhaust valves, sent electrical signals

Compatibility of Synthetic Lubricant Base Oils

Plastic and Elastomer Compatibility for Base Oil Families: G = Good; F = Fair; P = Poor

Solvent Compatibility for Base Oil Families: S = Soluble in large fraction; W = Weakly soluble; V = Varies with grade; I = Insoluble

	Plastic (see notes 1 and 4)																Elastomer (see notes 2 and 4)								Solvent (see notes 3 and 4)									
	Acetal	ABS	Phenolic	Polyamide-imide	Polyamide (nylon)	Polycarbonate	Polyester	Polyetherimide	Polyethylene	Polyimide	Polyphenylene oxide	Polystyrene	Polysulfone	PTFE	Polyvinyl chloride	Terephthalate	Buna S	Butyl	EPDM, EPR	Fluoroelastomer	Natural Rubber	Neoprene	Nitrile	Silicone	Water	Water plus detergent	Isopropanol	Methanol	Mineral Spirits	HCFC-141b	Fluoroalkane	Hydrofluorocarbon	Hydrofluoroether	Halogenated Blends
Synthetic Hydrocarbon Includes: polyalphaolefin (PAO) Viscosity Index (VI) = 125–250 Good lubricity	G	G	G	G	G	G	G	G	F	G	G	F	G	G	F	G	P	P	P	G	P	G	G	F	I	W	I	I	S	S	I	I	I	V
Polyglycol a.k.a. polyether Viscosity Index (VI) = 160–220 Low $/lb	G	P	G	G	G	P	P	G	F	G	P	G	P	G	P	G	P	P	G	G	P	P	F	G	V	W	V	V	S	S	I	I	I	V
Ester Includes: diester, polyolester Viscosity Index (VI) = 120–150 Excellent lubricity, load carrying	G	P	G	G	G	P	P	G	F	G	P	P	P	G	P	G	P	P	F	G	P	P	F	F	I	W	I	I	S	S	I	I	I	V
Silicone Includes: dimethyl-, phenyl-, halogenated- Viscosity Index (VI) = 200–650 Excellent (low) volatility	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	P	I	W	I	I	S	S	I	I	I	V
Halocarbon Includes chlorotrifluoroethylene (CTFE) Viscosity Index (VI) = poor Chemical resist. load carrying, low temp.	G	G	G	G	G	G	G	G	G	G	G	G	G	G	P	G	P	P	G	P	P	G	P	P	I	W	I	I	I	S	S	S	S	S
Fluoroether a.k.a. perfluoropolyether (PFPE) Viscosity Index (VI) = 100–350 Excellent inertness, lubricity, temp. range	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	I	W	I	I	I	S	S	V	V	V
Polyphenylether a.k.a. PPE Viscosity Index (VI) = 40–60 Excellent lubricity, volatility, rad. resist.	G	P	G	G	G	P	P	G	F	G	P	P	P	G	P	G	P	P	F	G	P	P	F	F	I	W	I	I	S	W	I	I	I	V

Note 1: For cross reference to trade names, consult *Modern Plastics Encyclopedia,'97*, McGraw-Hill Company, New York, 1997.
Note 2: For cross reference to trade names, consult *Blue Book 1996*; Lippincott & Peto, Akron, OH, 1996.
Note 3: Use of most organic solvents is subject to regulatory restrictions. Consult your plant safety officer for proper handling.
Note 4: Material compatibility can vary with mfgs. grade, lubricant grade, applied temp., and strain. **Nye Lubricants recommends that design engineers test all synthetic lubricants with any plastic or elastomeric component to ensure compatibility in their application.** Consult Nye Lubricants for more information.

A word to the wise

Choosing the right synthetic oil is the key to choosing the right synthetic lubricant. All oils — synthetic, animal, vegetable, and mineral — are liquids, which are subject to freezing and evaporation; in either state, the oil can't lubricate and the component fails *(See Figure 1, Base Oil Temperature Ranges)*. So matching the temperature range of an oil to the temperature extremes in which a component must operate is essential to selecting the right lubricant for an application.

Many people are comfortable when told to use a lithium grease. However, knowing you have a "lithium grease" really tells you little about the lubricant's temperature capabilities. All greases are made by mixing a powdered material, called a thickener, with a base oil; but it's still the oil that lubricates and it's still the oil that determines the temperature capabilities of the grease. The grease can be thought of as a "sponge of oil." Moving parts "squeeze" the oil out of the grease to prevent friction and wear. Since the lithium is only the "sponge," it will behave very differently depending on what oil is gelled with it. So, whether you're using a synthetic oil or a synthetic grease, consider the temperature range of the base oil, not the thickening agent, when specifying a lubricant for a component.

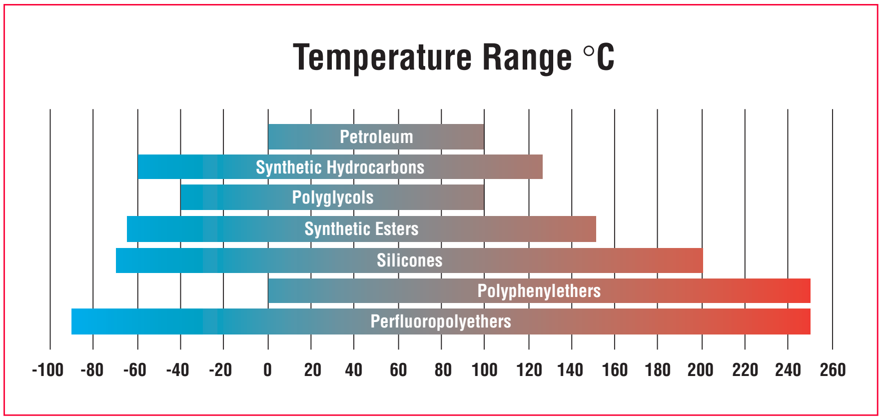
to a computer, which used the data about valve position to optimize performance. The signals had to be accurate, despite the fact that the sensor had to operate in wide temperature ranges, exposed to fuel and exhaust vapors. Greases were applied to the resistive elements because a small amount of wear on the ink may change the electrical signal that was sent to the computer. If the grease dried, varnished, froze, or was dissolved by fumes, the potentiometer was doomed — and so was the performance of the engine. Synthetic esters, silicones, and fluorinated oils helped ensured the reliability of these sensors.

Today there are dozens of sensors around a car. Many have been added underhood and under the car to monitor a wide variety of functions. A surprising number are used inside the passenger compartment. Some, like the oil pressure sensor (OPS), send information from under the hood directly to the driver. Positioning sensors alone are found in fuel tanks, steering columns, seats, exterior mirrors, accelerator pedals, as well as in active suspension packages. The right lube in each of these sensors can mean the difference between long-life operation or a trip to the dealership.

CONNECTION PROTECTION

During the last 15 years the use of automotive wire harnesses has grown at an exponential rate. Not only did sensors need to be plugged into computers, the growth of power features, switches, and lighting requirements has also helped multiply the number of wire harnesses in today's vehicle. As the number of harnesses grew, the need for cost-effective metals, smaller terminals, and more terminals per connector also grew. These changes, combined with wider operating temperatures, multiple low current signals, and higher reliability requirements presented connector engineers with new challenges. Synthetic greases were developed to meet those challenges— by offering superior connection protection.

In the winter season, a car is started cold, as low as -40°C. Engine temperatures can quickly climb to over 100°C. When the car is shut off, it returns to subzero conditions. Over time, this rapid thermal cycling causes the metal surfaces of mated connectors to build up oxides that degrade the electrical signal.



Lubricant Temperature Ranges

Synthetic lubricants withstand much broader temperature extremes that mineral-based lubricants. It's important to pick a base oil whose temperature range matches the operating environment of the component.

Vibration from nearby components — motors or fans, for example — can cause the same type of corrosion. Either case is a phenomenon known as fretting corrosion.

The use of gold or other non-oxidizing metals, or increasing the contact pressure on each mated terminal, can minimize fretting corrosion; but those are costly solutions, generally reserved for only very critical circuits, like the ones in air bags. However, synthetic hydrocarbon and silicone greases can achieve the same results at a significantly lower cost. They also serve two other functions. They reduce the force needed for mating and unmating connectors (some have as many as 100 terminals) by as much as 80 percent. If the grease is designed to be salt water and chemical resistant, it also serves as a back-up protection system, virtually eliminating environmental corrosion for the life of the component. Even with rubber seals this is an important consideration because heating and cooling of the connector housing still allows moisture to get inside and cause problems.

"YOU WANT TO PUT GREASE IN MY WHAT?"

Most people feel comfortable using grease on bearings, gears, slides, and other mechanical devices. Many don't recognize how a grease can also extend the life of electrical switches. Years ago, electrical relays with butt contacts were used to turn many devices in a car on and off. However, the need to reduce cost and the number of parts on a car pushed electrical engineers to make a better switch. While some relays are still used, most control is handled by the switch.

Some switches are designed to handle very low electrical currents to send signals to relays or computers. Some are designed to carry very high electrical loads, 20 to 60 amps, to starters, headlights, and turnsignals. More and more switches are expected to do both — and to do it across a wide temperature range and, for a safety margin, for 3 times the forecasted life. This might involve hundreds of thousands of cycles.

Low current switches don't require much metal to do the job, so they don't have much contact force. The proper contact grease can make all the difference. It has to be light enough to allow good electrical contact, not freeze in subzero environments, which causes the contacts to separate by hydroplaning, and it can't dry or varnish, causing poor conductivity. Light viscosity synthetic hydrocarbons and esters, which perform well at and below -40°C, have been very successful lubricants in low current switches.

High current switches have large metal contacts to carry the electrical load. When the contacts mate and break there may be a fair amount of arcing. This arcing super-heats the grease. It actually burns many greases and heats up the metal contacts. So heat is the target when selecting high current switch lubricants, and synthetics can take the heat. They actually take the heat in different ways. Glycols are relatively clean burning, which minimizes carbonizing residue on contacts. Esters are slow burning. They withstand higher temperatures longer than synthetic hydrocarbons, and do not polymerize as radically. PFPEs are non-burning, a feature that is attracting increased interest from OEMs and switch manufacturers for critical applications.

Switches that carry both high and low current often require different contact greases — one for the low current and one for the high. Many switch designs don't allow for two greases, but the flexibility of synthetics often allows one grease to do both.

Finally, the best mechanical lubricant would never allow two surfaces to make contact, thereby eliminating friction and wear. However, that scenario would prevent electricity from flowing from one switch surface to the other. Since contact must be made, contact wear debris will be created. Too much wear debris can cause more problems. So care must be taken when choosing a switch lubricant. Synthetic hydrocarbon, esters, and fluorinated lubricants get the job done.

CABLES SMOOTH AS SABLES

More than a dozen cables can be found on most cars. They vary in length, load carrying capability, and duty cycle. However, they have a few things in common. They are hand-operated, have long stranded bundles of wire inside a plastic sleeve, and if they don't work properly, the car owner gets greatly annoyed.

The beauty of the cable is its flexibility. It can be wrapped through and around all kinds of obstructions in the car. This erratic path causes a great deal of friction between the stranded wire and the plastic sleeve. The right lubricant is critical to keep friction at a minimum. The natural sliding action which tends to squeeze the lubricant out of the space between the wires and the plastic sleeve can make cables difficult to lubricate properly. The right lubricant should get in between those parts quickly, particularly on frequently used accelerator, brake, clutch, and shifter control cables — which often have to pass 1,000,000 stroking cycles before a design is accepted.

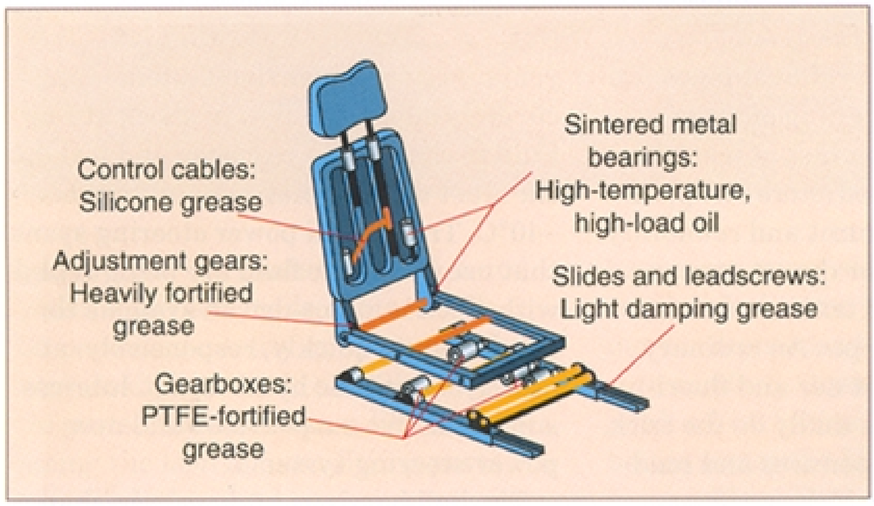
All cables must also operate efficiently at subzero conditions, and those routed to the engine compartment must also tolerate very high temperatures near the exhaust manifolds. Other cables, like parking brake and hood release cables, can sit for weeks or months without being cycled. They require the long-idle lubricant to work the first time, every time.

The near-universal solution for cable lubrication is silicone. Silicone oils and greases offer wide temperature and good surface-wetting characteristics. While cable lubricants are not exclusively silicone based, it is rare not to find some type of synthetic lubricant on these popular parts.

SCOTTY, I NEED MORE POWER

Electric motors have been used for years on cars to power both essential and luxury components. Some of today's cars have over 60 electric motors! Over the years, these motors have been designed smaller. Not only does a smaller motor reduce the weight and cost of the component, it provides a more efficient use of electricity by causing less drain on the rest of the electrical system.

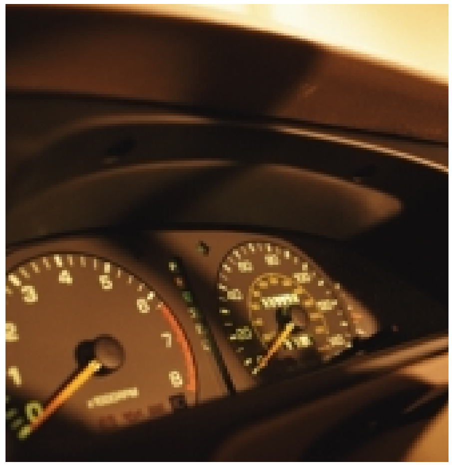
Starter motors are a good example of high output motors that have undergone significant size reduction in recent years. Yet, they still need to start six, eight or even 10 cylinder engines. In addition, they are exposed to road splash, grime, and 150°C exhaust pipes are routed close by. Despite the miserable operating environment, engineers have to make sure these motors last at least 10 years, because if these motors don't work, the car can't even be driven to a dealership for repair!



One System, Five Lubricants
Often there are several components in one system. This driver's seat system contains cables, gears, sintered metal bearings, slides, and lead crews. Different synthetic lubricants are available to meet the operating conditions of each component.

Other underhood motors strapped with the same environment and reliability issues include exhaust pump motors, cooling fan motors, ABS and traction control motors, and windshield wiper motors. An ordinary grease won't cut it, but ester and fluorinated greases and oils usually do the trick.

While extreme temperatures and road grime aren't issues inside the passenger compartment, the weight, power output, long life, and low noise are. Windowlift motors are a good example. The trend over the years has been to make the inside of the car quieter. One measure was to make the rubber window seals fit tighter against the glass to reduce outside noise. This requires the windowlift motor to have much higher output without changing its size. Synthetic greases and oils based on synthetic hydrocarbons and esters with the proper low friction and noise reducing additives, have done a nice job with power output efficiency and low noise on all interior motors.



ACTUATORS
ABS
Air Bag Clock Spring
Climate Control
Cup Holders
Door Lock
Exterior Mirror
Grab Handles
Hinges
Key Cylinders
Latches
Pedals
Power Sliding Door
PRNDL
Seat Position
Springs
Vent Controls
Visors
Window Lift

CABLES
Brake
Climate Control
Clutch
Exterior Mirror
Fuel Door Release
Hood Release
Parking Brake
Seat Recline
Speedometer
Sunroof
Throttle
Transmission
Trunk Release
Window Regulator

CONNECTORS
ABS
Airbag
Alternator
Battery
Cooling Fan
ECM/ECU
EGR
Firewall
Fuel Sender
Headlamp/Tail lamp
Mass Air Flow
Multifunction Switch
O_2
Speakers
Starter
TPS
Transmission Range Sensor
Wheel Speed Sensor

MOTORS
ABS
Antenna
Cooling Fan
Electric Brake
Electric Steering
ETC
Fuel Pump
HVAC Blower
Power Mirror
Seat
Starter
Sunroof
Suspension
Trunk Pulldown
Window
Wiper

POWERTRAIN
ABS
Alternator
Caliper
Clutch
Condenser
CV Joint
Differential
Drum Brakes
Fuel System
Idler Pulley
Idle Air Actuator
Master Cylinder
Shifters
Slip Yokes
Supercharger
Throttle Plate
Transfer Case
U Joints
Water Pump
Wheel Bearings

SENSORS
Exhaust Gas Recirculating
Fuel Level
Oxygen
Oil Pressure
Pedal Position
Power Mirror Position
Seat Position
Steering Position
Suspension Position
Temperature
Throttle Position
Transmission Speed
Wheel Speed

STEERING AND SUSPENSION
Ball Joint
Idler Arm
Intermediate Shaft
Manual Steering
Pitman Arm
Power Steering Gear
Rack and Pinion Steering
Shaft Bearings
Shock Absorbers
Stabilizer Bushings
Steering Yoke
Strut Bearing
Tie Rods
Tilt and Telescope

SWITCHES
Airbag Cutoff
Climate Control
Dash panel Dimmer
Dual Stalk
Hazard
Headlamp
Ignition
Multifunction
Power Lock
Power Mirror
Power Seat
Reading Lamp
Rear Defrost
Transmission Range Select
Trunk Release
Turn Signal
Window Lift

Synthetic Lubricants for Automotive Components

Lubricant engineering is both an art and a science. Today, if lubricant engineers understand an application thoroughly, they can custom-design a lubricant to match the operating conditions of a specific component. Above are many of the automotive components for which synthetic lubricants have already been developed.

FROM ENGINE OIL TO POWERTRAIN GREASES

While the general public is starting to accept synthetic engine oil and transmission fluid because they last longer and work better in subzero conditions than petroleum-based lubricants, there are a wide variety of other parts involved in a powertrain system that can also benefit from synthetic lubricants. If greases in underhood components, like alternators, condensers, and water pumps, minimize frictional drag, fuel economy is optimized. Clutch and brake systems, fuel and air controls, and even superchargers and turbochargers — all tested at 150°C and higher for long periods of time — will take the heat much longer with synthetic lubricants. Generally, esters, silicones, and fluorinated greases are used to meet the performance targets. In addition, synthetic hydrocarbon greases are significantly extending the life and improving the efficiency of CV joints, U joints in rear axles, and wheel bearings.

A BUMPY ROAD AHEAD

Steering and suspension systems have become much more complex in the recent years. Active suspension systems that accurately adjust the flow of shock absorber fluid to change the response and feel of the car must use oils that are fluid at -40°C and below. Traditional power steering systems that use hydraulic fluid are starting to be replaced with electric motor-driven systems that must actuate quickly, responsively, and quietly. Synthetic hydrocarbon lubricants support those design objectives.

The ball bearings and gears in these systems place a high demand on the lubricants. Ball joints in the front end suspension systems used to have grease fittings on them. When a car got an oil change it also got a chassis lube, which entailed pumping these joints with fresh grease because the original grease was used up. Today, the grease fittings are gone and these parts are "lubed for life," a 10 year life or longer. Synthetic hydrocarbons, esters, silicones, and fluorinated lubricants have allowed this new maintenance-free ability.

WHAT'S LEFT?

Many of the parts not yet mentioned are light-duty, hand-operated knobs, buttons, and various other controls and devices. While they do not have extreme temperature requirements, they all must feel and sound good — and operate at subzero temperatures and 3 times normal life. For mass fabrication and lower cost, many of them are made of plastic. But if plastic parts don't feel and sound good, perceived quality takes a nose-dive. Greases based on high viscosity synthetic oils can make a big difference. They behave like molasses — to reduce the lash of loose fitting parts, absorb audible sound, and give parts a controlled tactile response. In a nutshell, they improve perceived quality as well as reduce friction and wear. While most high viscosity lubricants become more viscous when cooled, and approach a solid state at -40°C, specially formulated "damping greases" can operate under those conditions. Typically, they are formulated using synthetic hydrocarbon and silicone oils.

So, the next time you operate a plastic switch, a temperature control, a shift knob, a cupholder, an ashtray, a window visor, or rear view mirror, if it feels and sounds great, it probably has a synthetic damping grease somewhere inside.

WHAT'S NEXT?

Cars of the next millennium will certainly require more efficient use of electricity from all of the power consuming components, especially with the battery powered vehicles. There will be more sensors, more wire harnesses, more weight reduction and increased fuel economy, more computers and screens, more creature comforts that must feel and sound good, longer life requirements, longer warranties, hotter underhood temperatures as the engine compartment gets smaller, and perhaps cold temperature requirements lower than -40°C. Add technologies like the fiber optics, which also use synthetic oil-based gels to improve signal transmission at the end of each fiber. Throughout the tightening of quality standards, synthetic lubricants will continue to play an ever more important role. They'll help engineers meet performance requirements of every moving part, and some non-moving parts. And like they have for the last decade, they will play an ever-more important role in keeping the auto industry — and the vehicles and they produce — moving. ■

About the author: Brian Holley, National Sales Manager at Nye Lubricants, Inc., can be reached at Nye's automotive office in Detroit at (248) 597-0077 or at bholley@nyelubricants.com.)