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Technical Service Bulletin

Product Description: AMSOIL Severe Gear (SVG, SVO) and AMSOIL Long Life (FGR, FGO)

Subject: Operating Conditions of Differentials

OBJECTIVE:

To define the operating conditions of differentials in various types of vehicles or markets, and provide the best AMSOIL gear oils for those applications.

ISSUES:

In recent years, the auto industry has increased engine torque and horsepower, while at the same time improving body aerodynamics and increasing cubic feet of interior space, causing less undercarriage space for air-cooling around the differential. Differential size and oil capacity has not increased, causing a more severe environment than in past years.

This has inspired thought as to what is the industries most severe operating environment for differentials.

TECHNICAL DISCUSSION:

Operational conditions of differentials are different in each of the 4 groups of vehicles.

1. Over The Road (OTR), Medium, and Heavy Duty Trucks
2. Off-Road Heavy Equipment
3. Light Duty Trucks, Turbo Diesel Trucks, SUVs, and Vans
4. Automobiles

Examining comparisons, tests, and original equipment manufacturer (OEM) trends in these categories will provide important information as to operating conditions associated with each group of ve-

hicles. After this examination, it will be clear which groups require a severe gear oil formula, and which require a long life formula.

Over The Road Trucks

Over the road (OTR) truck manufacturers have extended differential gear lube drain intervals up to 500,000 miles (see reference 1 & 2). To achieve drain intervals up to 500,000 miles, the OEMs were forced to recommend synthetic gear lube. These synthetic gear lubes are recognized as superior (see reference 3) and must meet or exceed specifications such as Dana SHAES 256, and Mack GO-J+. The extended drain intervals are possible because of many factors like those listed below.

- Large oil capacity (4 to 6 gallons)
- Large gears/gear face surfaces
- Synthetic lubricants
- Constant duty cycle
- Low gear oil temperatures
- Large tire diameter
- Slow gear rotation
- Exhaust is not routed by the differential
- Unrestricted air flow for cooling

Tests (see reference 5) show that OTR trucks pulling 75,000 to 80,000 lbs. can see differential temperatures of 80°F to 100°F higher than ambient temperatures or up to about 200°F gear lube temperature. Newer and more aerodynamic body styles do not significantly reduce air circulation or increase differential temperatures. When compared to automotive gear lube temperatures, these temperatures are cool and will contribute to long oil drain intervals.

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Page 1 of 5



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Off Road Heavy Equipment

Off road heavy equipment differentials perform at a lower speed than automotive differentials, yet have a gear face surface area similar to OTR truck differentials. In most cases these differentials run at similar temperatures to the OTR truck differentials. Higher gear loads than OTR trucks are generated by increased torque, which can cause gear oil temperatures of up to 250°F (see reference 6). While off road heavy equipment is built for dirty and dusty conditions, the temperatures seen in its differentials approach severe.

- Towing in temperatures over 70°F, under load, over 45 MPH
- Stop-and-go duty cycle
- Heavy loads
- Off-road driving
- Commercial use
- Driving in dusty conditions
- Short trips
- Steep hill driving
- Hard acceleration
- Sustained high speed driving
- Driving in extremely hot or cold temperatures (above 80°F and below freezing)

Light Duty Trucks, Turbo Diesel Trucks, SUVs, Vans

Differentials in light duty trucks, turbo diesel trucks, SUVs, and vans, (including conversion vans) run much hotter than OTR trucks or off road heavy equipment. Currently OEMs are shortening oil drain intervals and/or requiring synthetic gear oils due to increasing gear oil temperatures. Prior to 1985, some OEMs paid no attention to differential oil drains. Due to hotter running differentials, from 1986 to 1994 OEMs began to pay more attention to differential oil drains and recommended 100,000-mile oil drain intervals. More recently, some OEMs have reduced the oil drain interval to 3,000 miles if a petroleum oil is used in a severe service application while maintaining the 100,000-mile drain interval for synthetic gear lubricants. Currently, OEMs apply oil drain intervals based on the type of driving conditions. Severe service driving conditions are defined as any of the following:

Any one of the severe service conditions listed above can contribute to higher gear lube temperatures. In addition, today's body styles contribute to higher gear lube temperatures by restricting air flow around the differential (see reference 4). These higher gear lube temperatures can cause a phenomenon known as thermal runaway. Thermal runaway starts when a differential gets hot causing the oil to thin out. This allows for gear face contact, more friction and even more heat. This elevated heat further thins the oil, and the cycle repeats until extreme wear up to gear failure occurs.

Normal gear lube temperatures for light duty trucks, turbo diesel trucks, SUVs and vans are 170°F to 230°F. Towing creates even hotter gear lube temperatures, in the range of 250°F to 320°F, with extreme temperatures seen as high as 400+°F (see reference 5). Temperatures that can reach these extremes require a severe service gear lube.

Submitted By: KD Reviewed By: DY Approved By: Alan Amatzio Approval Date: 01/07/2005

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Page 2 of 5

Date: 01/07/2005

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Differentials in automobiles tend to be smaller than those in light duty trucks, turbo diesel trucks, SUVs and vans. Small differentials tend to run at higher temperatures. Other factors that add to increased differential heat in automobiles are:

- More aerodynamic body styles (which restrict air flow)
- Large passenger compartments (restricting undercarriage space and thus reducing air flow)
- High thermostat temperatures (leading to a higher ambient temperature in the air surrounding the differential)
- High horsepower
- Small gear face surfaces
- Small oil capacity
- Towing
- Exhaust muffler and pipes increase heat around the differential

Normal gear lube temperatures in range from 180°F to 230°F, and temperatures of 300°F (see reference 5) have been seen when towing as little as 1,500 lbs. up slight grades. These temperatures require a severe service gear lube.

Drain Intervals:

Medium and heavy-duty differential OEMs and light duty trucks, turbo diesel trucks, SUVs, vans, automobile differential OEMs are moving in opposite directions. Medium and heavy duty truck oil drain intervals are now up to 500,000 miles. Meanwhile, light duty truck, turbo diesel truck,

SUV, van, and automobile oil drain intervals are now shorter than just a few years ago. Recommended oil drain intervals in these vehicles have changed from factory fill for life to 3,000 miles severe service with petroleum gear oils and 100,000 miles with synthetic gear lubes. It is apparent that light duty trucks, turbo diesel trucks, SUVs, vans, and automobiles operate in the most severe environment, while off road heavy equipment operates in a moderately severe environment and OTR trucks have the least severe environment but require longer drain intervals.

“Higher horsepower, smaller, hotter running differentials are pushing the limits at which petroleum oils can be used to successfully satisfy the lubricant and equipment service life required by consumers and operators,” (see reference 3). Therefore, all OEMs currently recommend the use of synthetic gear lubes to achieve longer oil drain intervals and to address high temperature and severe service concerns.

RECOMMENDATIONS:

AMSOIL Synthetic Severe Gear SAE 75W-90 and 75W-140 gear lubes are designed for differentials used in severe service conditions and should be used for light duty trucks, turbo-diesel trucks, SUVs, vans, and automobiles. These gear lubes may also be used for class 8 heavy-duty trucks since these oils were designed to prevent thermal runaway with additional extra EP agent added to the product.

AMSOIL Synthetic Long Life SAE 75W-90 and 80W-140 gear lubes are designed for up to 500,000-mile oil drains in class 8 heavy-duty

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Page 3 of 5



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Subject: **Operating Conditions of Differentials**

trucks. These gear lubes may also be used for light duty trucks, turbo-diesel trucks, SUVs, vans, and automobiles for oil drains of up to 100,000-miles,

AMSOIL recommends gear lubes based on the application requirement. Please see Table I for additional information.

References:

Industry Specifications:

- 1). Dana SHAES 234 (250,000-mile oil drain) and 256 (500,000-mile oil drain requirements Arvin/Meritor axle division
- 2). Mack GO-J (250,000-mile oil drain) and Mack GO-J+ (500,000-mile oil drain)

Publications:

- 3). "Synthetic Lubricants and High Performance Functional Fluids"
1999, Second Edition, Marcell-Dekker, NY., Rudnick, Leslie R.; and Shubkin, Ronald L.
- 4). "SAE Technical Paper Series 881738"
Improvement of Rear Axle Cooling Performance Passenger Car Meeting and Exposition
Dearborn, Michigan Oct, 31 – Nov, 3, 1988
Shigeru Ogino; Shigetomi Kobayashi; and Shunkichi Suzaki; Toyota Motor Corporation

Industry Contacts:

- 5). Class 8 differential temperatures, automotive differential temperatures, dynamometer tests
Larry Eckhart
SWRI
May 18, 2004
- 6). Axle temperature tests
Bob Dunn
Meritor-Off Road Division
May 19, 2004

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Table I

AMSOIL Synthetic Gear Lube Recommendations *						
Application	Over-The-Road Truck Differentials	Heavy Equipment Differentials	Medium Duty Truck, Bus, Delivery/Utility Vehicle Differentials	Light-Duty Truck, SUV, Turbo Diesel Differentials	Personal Passenger Car Differentials	Special Use, Racing, 4x4 Offroad & Police Car Differentials
Recommendation F I R S T S E C O N D T H I R D (S A E 8 0 W - 9 0)	FGR, FGO	SVG, SVO	SVG, SVO	SVG, SVO	SVG	SVG, SVO
	SVG, SVO	FGR, FGO	FGR, FGO	FGR, FGO	FGR	FGR, FGO
	AGL	AGL	AGL	AGL	AGL	AGL

AMSOIL has optimized gear lube performance for specific operating conditions. However, AMSOIL gear lubes are multi-functional and may be used in many different applications. This chart conveys the best AMSOIL recommendation based on product design and operating environment.

First row product recommendations offer *superior* performance in the respective applications. Second row product recommendations offer *excellent* performance in the respective applications. The third row is exclusive to SAE 80W-90 viscosity.

AMSOIL Severe Gear™ 75W-90 (SVG) and 75W-140 (SVO) synthetic gear lubes have a performance emphasis on the extreme pressure and high heat of today's vehicle differentials.

AMSOIL Long Life 75W-90 (FGR) and 80W-140 (FGO) synthetic gear lubes have a performance emphasis on 500,000 mile extended drain intervals associated with larger sumps and lower operating temperatures of over-the-road truck differentials.

AMSOIL 75W-90 synthetic gear lubes will outperform conventional 80W-90 gear oils in all applications and may be used as a replacement.