

FIELD STUDY



75W-90 Long Life Synthetic Gear Lube Study in Over-the-Road Applications



Overview

Modern differentials installed in heavy-duty, over-the-road (OTR) trucks pose significant challenges to lubricants. Today's differential lubricants must protect heavily loaded gears and bearings from shock loading, wear and the effects of thermal breakdown throughout extended 500,000-mile drain intervals. Lubricants installed in OTR applications incapable of meeting these requirements are largely considered outdated for modern OTR applications.

Objective

Demonstrate that AMSOIL 75W-90 Long Life Synthetic Gear Lube meets or exceeds the increased performance needs of differentials installed in heavy-duty, long-haul fleet applications practicing 500,000-mile drain intervals.

Methodology

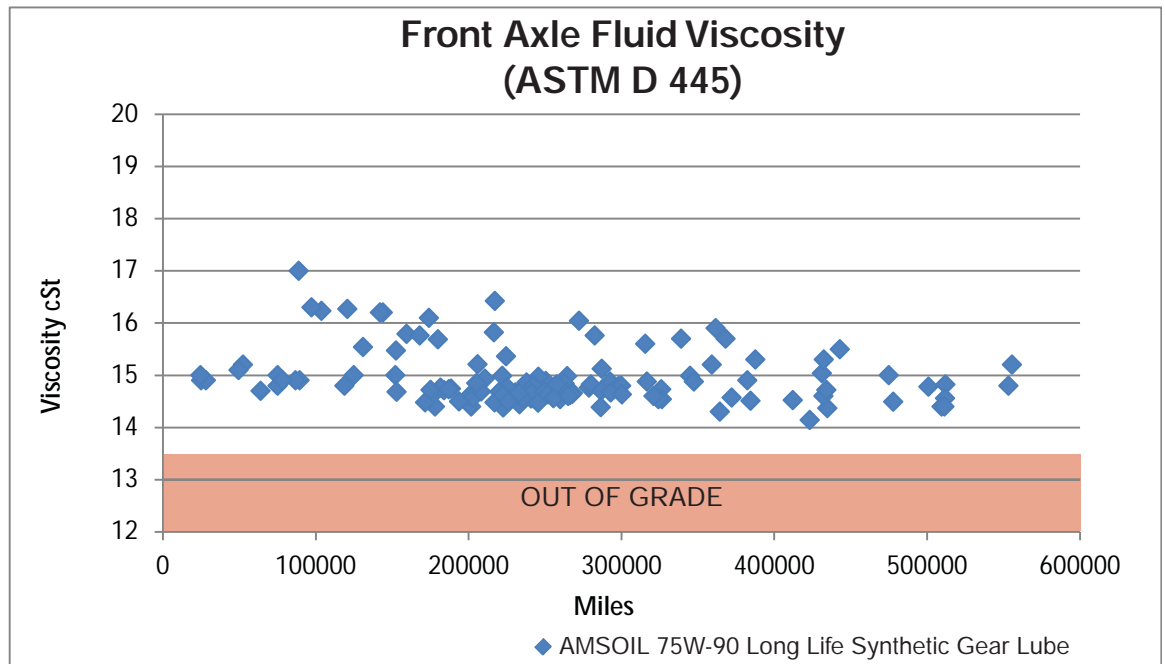
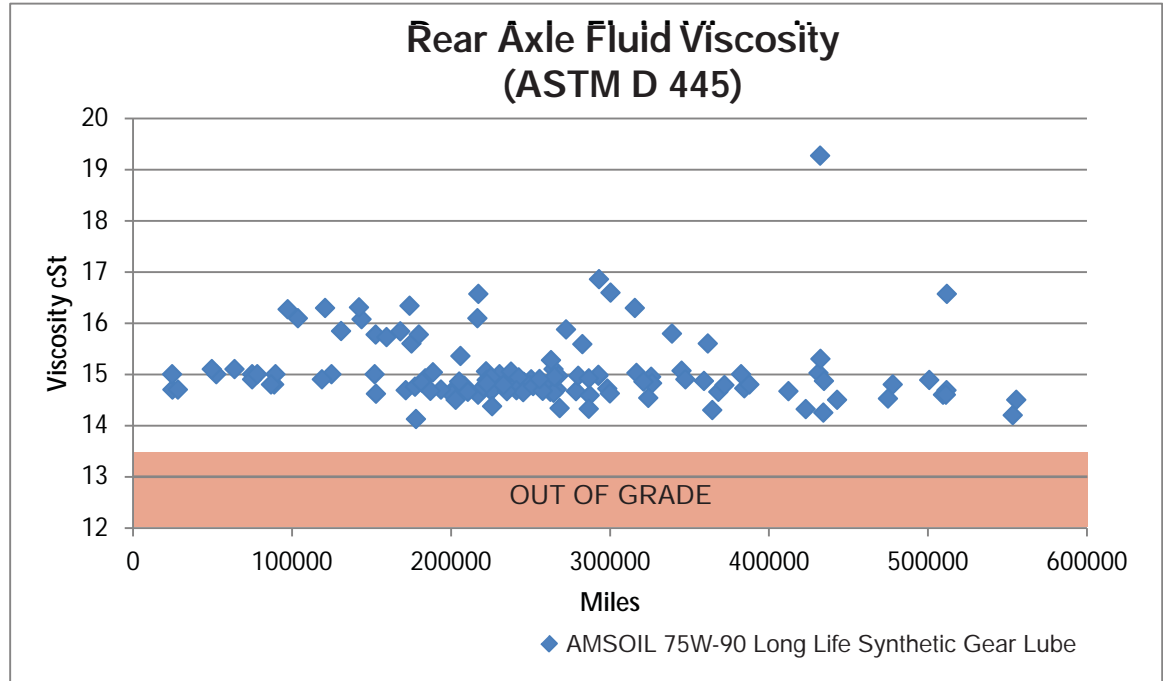
AMSOIL partnered with Superior, Wis.-based Jeff Foster Trucking, which hauls petroleum, aggregate, forest products and other freight throughout the contiguous 48 states and Canada. The fleet primarily hauls fully loaded 53' trailers through hot- and cold-temperature extremes. Vehicles routinely encounter demanding driving conditions, including stop-and-go city traffic and steep inclines, creating the ideal environment for testing gear lubricants.

Beginning in July 2006, AMSOIL 75W-90 Long Life Synthetic Gear Lube was installed in new model-year 2007 and 2008 Kenworth® trucks, most equipped with Spicer® differentials. The trucks were used by Foster Trucking between 2006 and 2011, during which lubricant samples were collected from a cross-section of vehicles at various mileage intervals. Oil analysis was conducted according to ASTM methodology to determine viscosity retention (ASTM D 445) and iron wear metal content (ASTM D 5185).

The front and rear differentials from unit 2168 were randomly selected and removed from service following 512,000 miles in service on a single lubricant change. They were then disassembled and rated for wear, sludge and other distress by an ASTM calibrated rater. Operating conditions for the front differential are generally more severe because it is constantly engaged, while the rear differential operates only when manually engaged by the driver. Therefore, results differ between the two differentials. This paper displays oil analysis results for AMSOIL 75W-90 Long Life Synthetic Gear Lube and photographic results and analysis of the differential disassemblies.

Oil Analysis – Viscosity Retention

The constant churning action of gears inside heavy-duty differentials can cause the gear lubricant to permanently lose viscosity due to mechanical shear. Excessive viscosity loss impairs the oil's ability to form a protective lubricating film between metal parts.

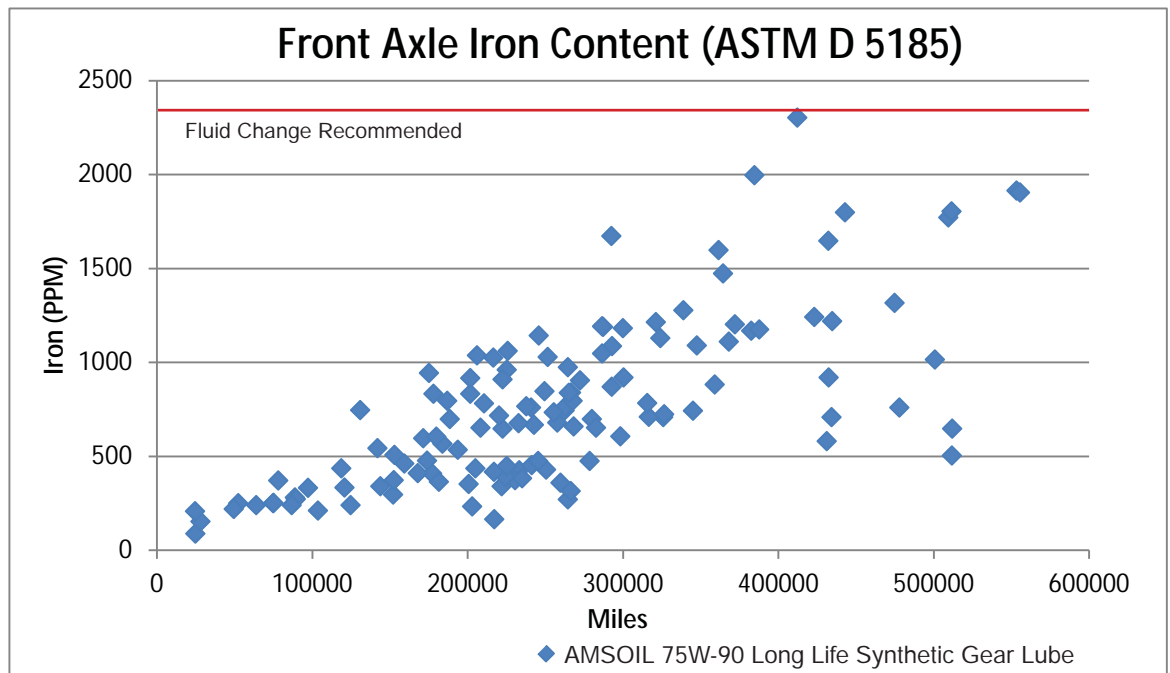
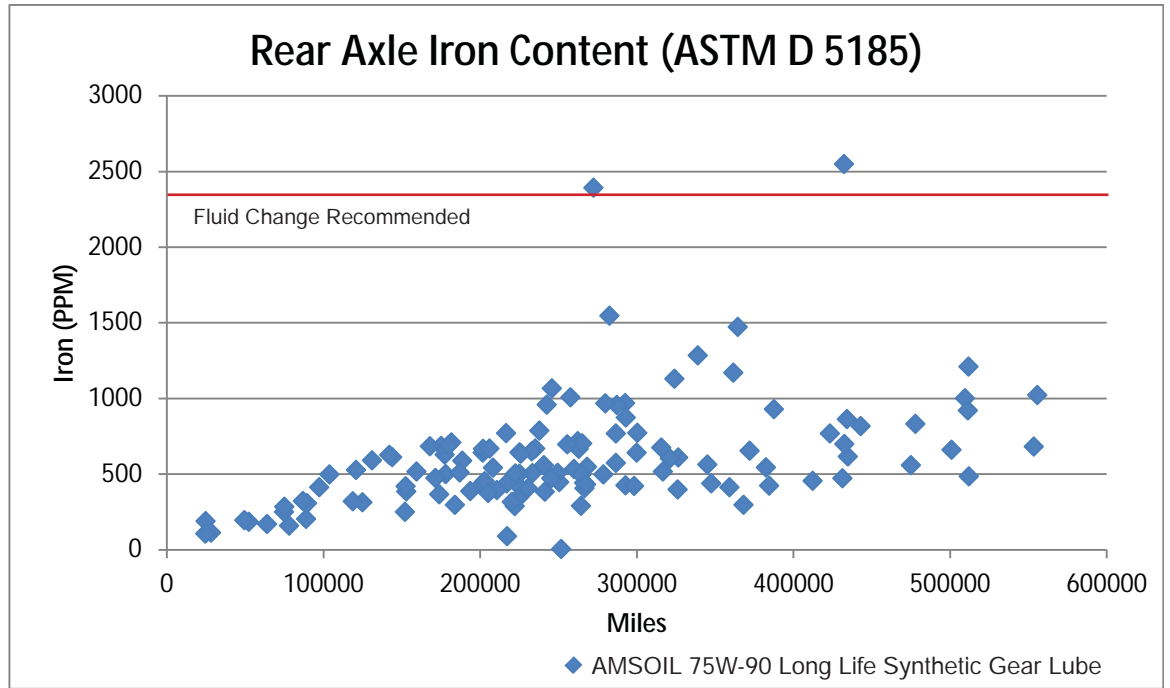


Results

Oil analysis indicated that, on average, AMSOIL 75W-90 Long Life Synthetic Gear Lube demonstrated only 9.3 percent viscosity loss in the rear axle and 10 percent loss in the front throughout the field study. The lubricant remained above the 13.5 cSt viscosity limit for 75W-90 gear lubes in all instances, confirming its ability to resist shear and maintain its protective lubricating film even after 500,000 miles in service.

Oil Analysis – Iron Content

Heavily loaded OTR truck differentials can generate high levels of iron particles that, unless extreme, do not impede performance or component longevity. Oil analysis is used to determine the acceptable level of iron before a lubricant change is recommended. Polaris Labs, for example, a leader in oil analysis services for heavy-duty applications, determined 2,349 ppm the level at which a fluid change is recommended based on examination of historical data from similar applications.



Results

The ability of the lubricant to control iron wear metal generation is especially important in the front differential because it is engaged constantly, increasing stress. AMSOIL 75W-90 Long Life Synthetic Gear Lube limited iron to levels below the level at which a fluid change is recommended in the front differential in all instances, demonstrating strong wear protection. Protection in the rear differential was equally as high, with nearly all samples measuring below the threshold.

Differential Component Ratings

To further evaluate the performance of AMSOIL 75W-90 Long Life Synthetic Gear Lube, the front and rear differentials in unit 2168 were disassembled after accumulating 512,000 miles on the lubricant and evaluated by an ASTM calibrated rater. Each component was assigned a merit rating on a scale from 0 to 10, with 10 representing the absence of distress and 0 representing catastrophic distress (see table below). Rating criteria as defined in *ASTM Distress Rating Manual 21* were used and include burnish, wear, rippling, ridging, pitting, spalling, scoring, discoloration, corrosion, chipping and sludge (see table on page 6 for definitions). The following sections display the results.

| Numerical Distress Rating Scales for Gears | |
|--|--|
| Value | Level of Distress |
| 10 | None |
| 9 | Trace |
| 8 | Trace-Light |
| 7 | Light |
| 6 | Light-Medium |
| 5 | Medium |
| 4 | Medium-Heavy |
| 3 | Heavy |
| 2 | Heavy to Catastrophic (Up to 50% of the gear tooth surface not ratable) |
| 1 | Heavy to Catastrophic (Greater than 50% and less than 100% of the gear tooth surface not ratable) |
| 0 | Catastrophic (100% of the gear tooth surface not ratable) |

Table applies to gears and bearings.

“NR” designates no rating assigned by the ASTM calibrated rater.

| Gear Rating Definitions | |
|--------------------------------|--|
| Merit Rating | Definition of a distress or deposit condition in numerical terms on a descending scale from ten (10), which represents absence of distress. |
| Burnish | An alteration of the original manufactured surface ranging from a dull to a brightly polished condition. |
| Wear | The removal of metal, without evidence of surface fatigue or scoring, resulting in partial or complete elimination of tool or grinding marks and/or development of a discernible shoulder ridge at the bottom of the contact area near the root or at the toe or heel end of the pinion tooth contact area. |
| Abrasive Wear | Wear caused by lapping of mating surfaces by fine particles suspended in lubricant, fuel, air, or imbedded in a surface. |
| Adhesive Wear | Wear caused by shearing of junctions formed between operating surfaces in direct metal-to-metal contact; sheared-off particles either remain affixed to either the mating surfaces or act as wear particles between the surfaces. |
| Rippling | An alteration of the tooth surface to give an appearance of a more or less regular pattern resembling ripples on water, or fish scales. NOTE: Examination of the surface with oblique lighting usually is necessary to show this condition. |
| Ridging | An alteration of the tooth surface to give a series of parallel raised and polished ridges running in the direction of the sliding motion, either partially or completely across the tooth surfaces. |
| Pitting | Small irregular cavities in the tooth surface, less than 1 square millimeter, resulting from the breaking out of surface metal. |
| Spalling | The breaking-out of flakes or irregular area of the tooth surface, 1 square millimeter or larger; a condition more extensive than pitting. |
| Scoring | The displacement of metal by local momentary welding from the gear tooth, resulting in the development of a matte or frosted, dull surface. |
| Discoloration | Any alteration in the normal color of rated surfaces. |
| Corrosion | A general alteration of the finished surfaces by discoloration, accompanied by roughening not attributable to mechanical action. Rust is a special case of corrosion. |
| Chipping | Ring and pinion gears – A condition caused in the manufacturing process in which a small irregular cavity is present only at the face/crown edge interface. The edge chipping phenomenon occurs when sufficient fatigue cycles accumulate after tooth surface wear relieves the compressive residual stress on the tooth profile's side of the profile-to-topland interface. Chipping within 1 mm of the face/crown edge interface is to be called chipping, not pitting/spalling. |
| Sludge | A deposit composed of organic residue which may contain fuel, lubricant, and/or water. Such deposits will be found on surfaces operating at bulk unit temperature and exposed to fuels and/or lubricants. These deposits do not drain, but can be removed by wiping with moderate pressure using a clean, dry, soft, lint-free wiping material. Deposits rated as sludge may vary in characteristics – color, transparency, and consistency. |

Table taken from ASTM Distress Rating Manual No. 21

Front Axle Ring Gear



CLOSEUP

Merit Ratings

| Condition | Drive Side | Coast Side |
|---------------|------------|------------|
| Burnish | Dull | Dull |
| Wear | 9 | 9 |
| Rippling | 10 | 10 |
| Ridging | 10 | 10 |
| Pitting | 10 | 10 |
| Spalling | 10 | 10 |
| Scoring | 10 | 10 |
| Discoloration | 9 | 9 |
| Corrosion | 10 | 10 |

Results

Merit ratings for burnish are represented by qualitative terms ranging from *dull* to *brightly polished*. Greater levels of wear to gear teeth are denoted by brighter levels of burnish. Despite intense pressure and shock-loading conditions that can rupture the lubricant’s fluid film, inviting wear, the ring gear demonstrated only *dull* burnish. AMSOIL 75W-90 Long Life Synthetic Gear Lube also prevented rippling, ridging, pitting, spalling, scoring and discoloration. Wear was inhibited to a *trace* level, indicating the lubricant excelled in limiting metal-to-metal contact.

Front Axle Pinion Gear



CLOSEUP

Merit Ratings

| Condition | Drive Side | Coast Side |
|----------------------|---------------|---------------|
| Burnish | Medium Bright | Medium Bright |
| Wear | 8 | 9 |
| Rippling | 10 | 10 |
| Ridging | 10 | 10 |
| Pitting | 10 | 10 |
| Spalling | 10 | 10 |
| Scoring | 10 | 10 |
| Discoloration | 9 | 9 |
| Corrosion | 10 | 10 |

Results

The pinion gear earned perfect 10 merit ratings in six of eight applicable categories, while the lubricant limited wear despite the challenging operating conditions. The gear ratio (3.36:1) indicates each tooth on the pinion gear engages in contact 3.36 times more often than each tooth on the mating ring gear. The increased stress explains why the pinion gear earned a lower burnish rating (*medium bright*) compared to the front axle ring gear.

Front Axle Pinion Bearing



ROLLERS



CUP

Merit Ratings

| Condition | Cup | Rollers |
|-----------------|----------------|----------------|
| Wear | 8 | 8 |
| Scoring | 10 | 10 |
| Pitting | 8 ¹ | 8 ¹ |
| Spalling | 10 | 10 |
| Discoloration | 8 | 7 |
| Corrosion | 10 | 10 |
| Roller End Wear | NR | 7 |

¹Debris denting, not pitting

Results

Constant rotational stress, often under heavy load, results in elevated friction and heat that can shorten bearing life. The pinion bearing cup and rollers demonstrated no scoring, spalling or corrosion, while the lubricant limited wear to a *trace-light* level. AMSOIL 75W-90 Long Life Synthetic Gear Lube provided excellent protection.

Front Axle Helical Gears & Thrust Washer



HELICAL DRIVE GEAR



OUTPUT SHAFT
SIDE GEAR



THRUST WASHER



HELICAL DRIVEN GEAR

SIDE GEAR

Merit Ratings

| Condition | Helical Drive Gear | Helical Driven Gear | Side Gear | Output Shaft Side Gear | Thrust Washer |
|----------------------|--------------------|---------------------|-----------|------------------------|---------------|
| Burnish | Medium Bright | Bright | Bright | Bright | NR |
| Wear | 7 | 7 | 6 | 7 | 7 |
| Sludge | 6 | 8 | 6 | 7 | 6 |
| Ridging | NR | 8 | NR | NR | NR |
| Rippling | NR | 9 | NR | NR | NR |
| Pitting | 8 | NR | 7 | 7 | 7 |
| Spalling | NR | NR | 7 | 9 | NR |
| Discoloration | NR | NR | NR | NR | 8 |

Results

The front axle helical gears are engaged by the driver to connect the front and rear axles when added traction is needed. The design of helical gears allows them to bear increased loads and operate more quietly than other gear designs; however, increased loads also invite increased distress. AMSOIL 75W-90 Long Life Synthetic Gear Lube limited wear to both the helical drive gear and helical driven gear to a *light* level. The lubricant also inhibited burnish, ridging and pitting effectively. The side gear, located on the front of the helical driven gear, and the output shaft side gear also demonstrated a high level of protection.

By nature, the angular cut of helical gear teeth causes the gears to move outward during operation. The thrust washer absorbs the motion, creating wear conditions. AMSOIL 75W-90 Long Life Synthetic Gear Lube controlled wear to a *light* level, confirming the level of protection the lubricant provided.

Front Axle Spider Gears & Thrust Washers



SPIDER GEAR



THRUST WASHER

Merit Ratings

| Condition | Spider Gear | Thrust Washer |
|---------------|-------------|---------------|
| Burnish | Dull | NR |
| Wear | 7 | 8 |
| Rippling | 10 | NR |
| Ridging | 10 | NR |
| Pitting | 9 | NR |
| Spalling | 10 | NR |
| Scoring | 10 | NR |
| Discoloration | 9 | 9 |
| Corrosion | 10 | NR |

Results

The front axle spider gear exhibited no rippling, ridging, spalling, scoring or corrosion. AMSOIL 75W-90 Long Life Synthetic Gear Lube also controlled wear to a *light* level. The thrust washer earned a high merit rating for wear (*trace-light*), while discoloration was minimal.

Front Axle Side Gear & Thrust Washer



SIDE GEAR



THRUST WASHER

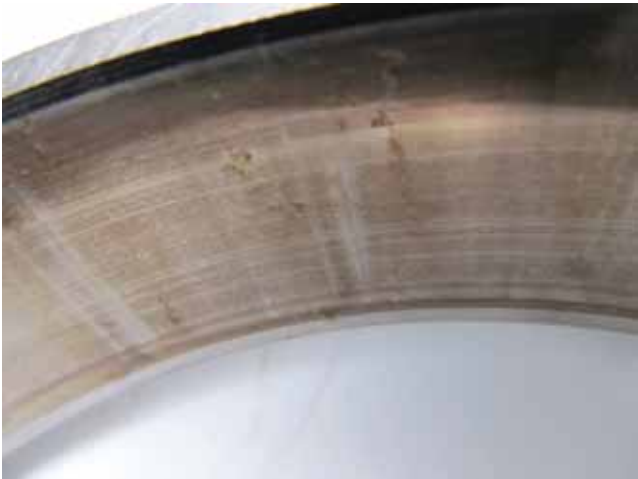
Merit Ratings

| Condition | Side Gear | Thrust Washer |
|----------------------|---------------|---------------|
| Burnish | Medium Bright | NR |
| Wear | 7 | 8 |
| Rippling | 10 | NR |
| Ridging | 10 | NR |
| Pitting | 10 | NR |
| Spalling | 10 | NR |
| Scoring | 10 | NR |
| Discoloration | 9 | 9 |
| Corrosion | 10 | NR |

Results

The front axle side gear earned perfect 10 merit ratings in six of eight applicable categories, while wear was effectively inhibited to a *light* level, confirming the lubricant excelled in limiting metal-to-metal contact between meshing gear teeth. AMSOIL 75W-90 Long Life Synthetic Gear Lube also protected the thrust washer effectively.

Front Axle Differential Bearing



CUP



ROLLERS

Merit Ratings

| Condition | Cup | Rollers |
|-----------------|----------------|----------------|
| Wear | 8 | 8 |
| Scoring | 10 | 10 |
| Pitting | 8 ¹ | 8 ¹ |
| Spalling | 10 | 10 |
| Discoloration | 8 | 7 |
| Corrosion | 10 | 10 |
| Roller End Wear | NR | 7 |

¹Debris denting, not pitting

Results

In the areas of scoring, spalling and corrosion, the front axle differential bearing received perfect merit ratings of 10, indicating AMSOIL 75W-90 Long Life Synthetic Gear Lube provided superior bearing protection. The merit rating for wear is also high, indicating the strong protection the lubricant provided.

Interaxle Differential Assembly



CROSS SHAFT



SPIDER GEAR

Merit Ratings

| Condition | Cross Shaft | Spider Gear |
|-----------|-------------|---------------|
| Burnish | NR | Medium Bright |
| Wear | 6 | 6 |
| Ridging | 7 | NR |
| Pitting | 8 | 5 |
| Sludge | 7 | 7 |

Results

When the interaxle differential assembly is operating, it distributes torque equally to both the front and rear axles. Both the cross shaft and spider gear demonstrated *light-medium* wear. Ridging and pitting were likewise controlled to acceptable levels for a heavy-duty differential having accumulated over 500,000 miles.

Front Axle Clutch Collar, Input Shaft & Shift Fork



CLUTCH COLLAR



INPUT SHAFT



SHIFT FORK

Merit Ratings

| Condition | Clutch Collar | Input Shaft | Shift Fork |
|-----------|---------------|-------------|------------|
| Burnish | NR | Dull | NR |
| Wear | 7 | 7 | 6 |
| Sludge | 6 | 6 | 7 |

Results

The clutch collar bears friction repeatedly, representing a component prone to wear. Similarly, the shift fork undergoes frequent sliding motion and can be an area prone to metal-to-metal contact. AMSOIL 75W-90 Long Life Synthetic Gear Lube limited wear to a *light* level on the clutch collar and a *light-medium* level on the shift fork. The input shaft demonstrated *light* wear as well, confirming the lubricant's high level of protection.

Rear Axle Ring Gear



CLOSEUP

Merit Ratings

| Condition | Drive Side | Coast Side |
|---------------|------------|------------|
| Burnish | Dull | Dull |
| Wear | 9 | 9 |
| Rippling | 10 | 10 |
| Ridging | 10 | 10 |
| Pitting | 10 | 10 |
| Spalling | 10 | 10 |
| Scoring | 10 | 10 |
| Discoloration | 9 | 9 |
| Corrosion | 10 | 10 |

Results

The rear axle ring gear demonstrated *dull* burnish and earned perfect 10 merit ratings in six of eight applicable categories. The ring gear exhibited only a *trace* level of wear and discoloration despite the increased pressure and shock loading encountered when the rear differential is engaged. AMSOIL 75W-90 Long Life Synthetic Gear Lube provided excellent protection.

Rear Axle Pinion Gear



CLOSEUP

Merit Ratings

| Condition | Drive Side | Coast Side |
|---------------|---------------|---------------|
| Burnish | Medium Bright | Medium Bright |
| Wear | 8 | 8 |
| Rippling | 9 | 10 |
| Ridging | 10 | 10 |
| Pitting | 10 | 10 |
| Spalling | 10 | 10 |
| Scoring | 10 | 10 |
| Discoloration | 9 | 9 |
| Corrosion | 10 | 10 |

Results

The rear axle pinion gear earned perfect 10 merit ratings in most categories, indicating the lubricant developed a strong lubricating film and inhibited distress. The gear ratio (3.36:1) indicates each pinion gear tooth engages in contact 3.36 times more often than each tooth on the mating ring gear. Given these conditions, the *medium bright* burnish rating is high, as is the *trace-light* wear rating.

Rear Axle Pinion Bearing



ROLLERS



CUP

Merit Ratings

| Condition | Cup | Rollers |
|-----------------|----------------|----------------|
| Wear | 8 | 8 |
| Scoring | 10 | 10 |
| Pitting | 8 ¹ | 8 ¹ |
| Spalling | 10 | 10 |
| Discoloration | 7 | 7 |
| Corrosion | 10 | 10 |
| Roller End Wear | NR | 7 |

¹Debris denting, not pitting

Results

The rear axle pinion bearing received excellent protection, earning perfect 10 merit ratings for scoring, spalling and corrosion. Despite elevated heat and rotational stress, pitting and wear were limited to *trace-light* levels, confirming the lubricant maintained protection throughout the service interval.

Rear Axle Side Gear & Thrust Washer



SIDE GEAR



THRUST WASHER

Merit Ratings

| Condition | Side Gear | Thrust Washer |
|---------------|-----------|---------------|
| Burnish | Bright | NR |
| Wear | 7 | 8 |
| Rippling | 10 | NR |
| Ridging | 10 | NR |
| Pitting | 10 | NR |
| Spalling | 10 | NR |
| Scoring | 10 | NR |
| Discoloration | 9 | 9 |
| Corrosion | 10 | NR |

Results

The rear axle side gear received perfect 10 merit ratings in six of eight applicable categories, indicating the high level of protection the lubricant provided. Wear was controlled to a *light* level. The thrust washer exhibited *trace-light* wear, confirming the protection provided by the lubricant.

Rear Axle Spider Gear & Thrust Washer



SPIDER GEAR



THRUST WASHER

Merit Ratings

| Condition | Spider Gear | Thrust Washer |
|---------------|-------------|---------------|
| Burnish | Dull | NR |
| Wear | 7 | 8 |
| Rippling | 10 | NR |
| Ridging | 10 | NR |
| Pitting | 10 | NR |
| Spalling | 10 | NR |
| Scoring | 10 | NR |
| Discoloration | 9 | 9 |
| Corrosion | 10 | NR |

Results

Burnish on the spider gear was inhibited to a *dull* level, while the gear received perfect merit ratings for rippling, ridging, pitting, spalling, scoring and corrosion. The lubricant limited wear to *light* levels. The thrust washer demonstrated only *trace-light* wear.

Rear Axle Differential Bearing



ROLLERS



CUP

Merit Ratings

| Condition | Cup | Rollers |
|------------------------|----------------|----------------|
| Wear | 8 | 8 |
| Scoring | 10 | 10 |
| Pitting | 6 ¹ | 7 ¹ |
| Spalling | 6 | 10 |
| Discoloration | 6 | 7 |
| Corrosion | 10 | 10 |
| Roller End Wear | NR | 7 |

¹Debris denting, not pitting

Results

AMSOIL 75W-90 Long Life Synthetic Gear Lube prevented scoring and corrosion to the rear axle bearing. The rollers likewise demonstrated no spalling, confirming the lubricant provided a high level of protection. Wear was inhibited to a *trace-light* level on both the cup and rollers.

Front & Rear Axle Seals



FRONT SEAL



REAR SEAL

Merit Ratings

| Condition | Front Seal | Rear Seal |
|------------|------------|-----------|
| Wear | 9 | 6 |
| Hardening | 10 | 10 |
| Reversion | 10 | 10 |
| Blistering | 10 | 10 |
| Cracking | 10 | 10 |
| Deposits | 9 | 9 |

Results

Both the front and rear axle seals earned perfect merit ratings for hardening, reversion, blistering and cracking. Deposits were limited to *trace* levels, while the front seal demonstrated only a *trace* level of wear. Results confirm AMSOIL 75W-90 Long Life Synthetic Gear Lube’s ability to provide excellent protection for seals.

Front & Rear Axle Cross Shafts



FRONT AXLE CROSS SHAFT



REAR AXLE CROSS SHAFT

Merit Ratings

| Condition | Front Cross Shaft | Rear Cross Shaft |
|---------------|-------------------|------------------|
| Burnish | Bright | Bright |
| Wear | 8 | 8 |
| Rippling | 10 | 10 |
| Ridging | 10 | 10 |
| Pitting | 9 | 10 |
| Spalling | 10 | 10 |
| Scoring | 10 | 10 |
| Discoloration | 9 | 9 |
| Corrosion | 10 | 10 |

Results

The spider gears rotate on the cross shafts, which are subject to shock loading and rotational stress. Both front and rear cross shafts earned perfect merit ratings for rippling, ridging, spalling, scoring and corrosion. The lubricant limited wear to *trace-light* levels, demonstrating its strong protective properties.

Conclusion

Used oil analysis results and a complete visual inspection of components from a front and rear differential by an ASTM calibrated rater demonstrate the effectiveness of AMSOIL 75W-90 Long Life Synthetic Gear Lube in over-the-road applications practicing 500,000-mile drain intervals. The gear lube effectively maintained viscosity despite 500,000 miles of rigorous use. Wear protection was likewise superior; samples of AMSOIL 75W-90 Long Life Synthetic Gear Lube contained minimal iron, indicating it maintained its protective lubricating film throughout service.

A complete disassembly and visual inspection of the front and rear differentials offers further proof of performance. The ring, pinion, spider and side gears in both differentials received perfect merit ratings of 10 for ridging, spalling, scoring and corrosion, indicating a complete absence of distress. The differential and pinion bearings earned perfect 10 ratings in the areas of scoring and corrosion, while wear was limited to *trace-light* levels. Ratings for other components prone to wear, including the helical drive gear, helical driven gear and thrust washers, were also high. Both the front and rear seals earned perfect 10 merit ratings in most categories, including blistering and cracking, and demonstrated no leaking throughout the study. In fact, none of the differentials in the field study filled with AMSOIL 75W-90 Long Life Synthetic Gear Lube demonstrated leaking. While synthetics were once thought to harm seals, these results confirm the high level of protection the AMSOIL lubricant provided differential seals.

Results of this field study prove AMSOIL 75W-90 Long Life Synthetic Gear Lube provides excellent protection in modern heavily loaded, over-the-road differentials throughout extended 500,000-mile drain intervals.



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