



Las Vegas Taxi Cab Field Study

An evaluation of AMSOIL Signature Series Multi-Vehicle Synthetic ATF and Signature Series Synthetic Motor Oil operated under severe-service conditions for extended drain intervals.

Second Edition
Published April 2014





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Editor's Note:

AMSOIL published the first edition of the *Las Vegas Taxi Cab Field Study* in April 2013. Results demonstrated the excellent performance of AMSOIL synthetic lubricants in severe-service commercial applications operating in the searing Las Vegas heat. The original transmission accumulated more than 102,000 miles on a single fluid change. To further test the capabilities of AMSOIL Signature Series Multi-Vehicle Synthetic Transmission Fluid, it was installed in another taxi that was operated for 12,891 hours (183,705 miles) – 3X original equipment manufacturer recommendations – on a single fluid change. Those results are presented here along with the engine results from the first edition of this study.

Overview

Few applications place more stress on lubricants than taxi cabs, particularly those operating in the desert heat of Las Vegas, Nev. The combination of excessive idling, stop-and-go driving and high ambient temperatures creates the ideal scenario for lubricant failure, resulting in sludge formation and catastrophic component failure.

Fleet vehicles, heavy-duty pickups, work trucks and other commercial applications operate under severe service. In addition, drain intervals are getting longer. For engines and transmissions to last as designed and achieve maximum performance, lubricants today must protect against elevated heat and its associated problems for longer periods of service.

Objective

Demonstrate that AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid and Signature Series Synthetic Motor Oil protect against extreme heat and sludge formation during extended drain intervals in vehicles routinely operated in severe conditions. Further demonstrate that the lubricants meet the increased performance demands of modern fleet, commercial and other professional vehicles.

Method

In conducting this field study, AMSOIL sought a test partner with vehicles used in the most demanding conditions possible. A Las Vegas taxi company was selected due to the challenges inherent to taxi applications and the extreme desert heat, which presented a worst-case scenario that further challenged the lubricants. In fact, the taxi company had been experiencing rampant engine failure using synthetic blend motor oil recommended for API SN/ILSAC GF-5 service requirements and changed every 5,000 miles. Engine failures occurred predominantly during hot summer months due to excess sludge clogging the oil pickup tubes and starving the engines of oil. The severity of service also required frequent transmission fluid changes (every 20,000 miles).

Signature Series Synthetic Automatic Transmission Fluid and Signature Series Synthetic Motor Oil were installed in six of the fleet's vehicles. The test vehicles were placed into service and operated within the fleet's service area of Las Vegas up to 24 consecutive hours each day, with the engines often shut down only during refueling or personnel changes. Excessive time idling combined with stop-and-go driving loaded with passengers and cargo characterized typical driving conditions. During summer months, ambient temperatures often exceeded 100°F, further increasing severity.

Motor oil in the test vehicles was scheduled to be changed at a minimum of 900-hour intervals. The actual motor oil change intervals for the engine reported in this study were 1,005 hours (approximately 15,000 miles). Transmission fluid was not changed in any of the vehicles.

Note: Oil change intervals were determined using hours rather than miles due to excessive idling and low-speed driving. In these conditions, hours of service provides a more accurate measure of the oil's service life. To illustrate the severity of service for the average motorist, 900 hours of total operating time is equivalent to 19,080 miles in city driving conditions and 43,470 miles in on-highway conditions.¹

Following testing, engine and transmission parts were rated for sludge, wear and other distress by an independent calibrated rater according to the criteria given in the appropriate Coordinating Research Council (CRC) manual. Parts were assigned a numeric rating on a descending scale, with 10 representing no distress and 0 representing catastrophic distress. Some parts were assigned a descriptive rating (e.g. "None", "Good", etc.) describing the level of distress. Results are divided into two parts, one for the transmission and the other for the engine.

Vehicles Selected for Teardown & Analysis

Engine

After accumulating 7,033 hours (102,582 miles) throughout 18 months of service, the 2.7L V6 engine from a 2010 Dodge Charger was disassembled and analyzed. The vehicle averaged 14.6 mph throughout 18 months of service, illustrating severity of service.

Transmission

Following 12,891 hours (183,705 miles) the 4-speed automatic transmission (model #42RLE) from a second 2010 Dodge Charger was removed from service for analysis. The vehicle averaged 14.3 mph throughout 27 months in service.

Both vehicles operated throughout the field study with the following lubricants:

Engine: AMSOIL Signature Series 0W-20 Synthetic Motor Oil

Transmission: AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid

¹ Conversion based on average mph in city driving (21.2) and highway driving (48.3) according to the Environmental Protection Agency's (EPA) Federal Test Procedure (FTP) Driving Schedule and Highway Fuel Economy Test (HWFET). See http://www.fueleconomy.gov/feg/fe_test_schedules.shtml.

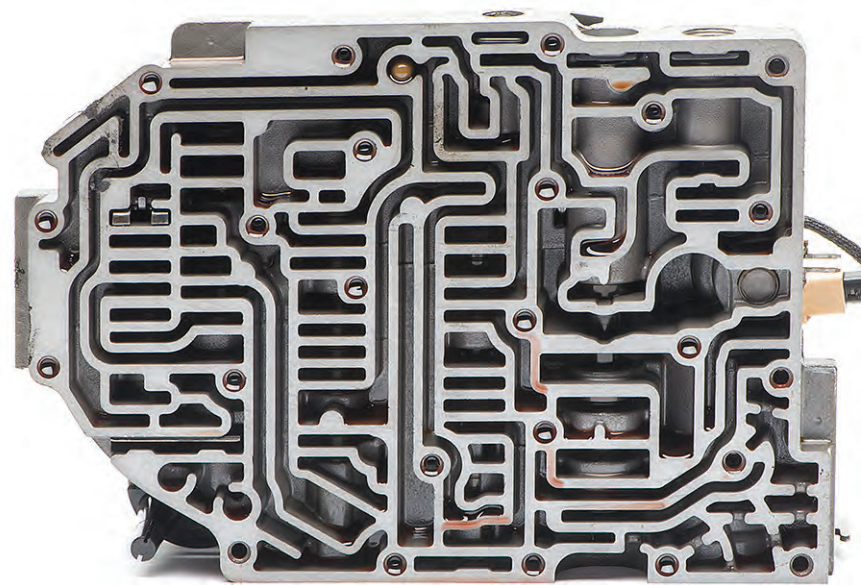
PART ONE

TRANSMISSION RESULTS

Although the taxi company typically changed transmission fluid every 20,000 miles, the drain interval in the test vehicle presented in this study using AMSOIL Signature Series Synthetic ATF was extended to more than 180,000 miles – 3X original equipment manufacturer recommendations – to increase severity.

Component Analysis & Ratings

Valve Body



Rating	
Valve Body Sludge Deposits	9.8

In addition to regulating fluid pressure, the valve body directs fluid for actuating the servos and clutch packs used in shifting. Due to the high number of narrow passages, the valve body is especially sensitive to the negative effects of fluid oxidation and sludge formation. The valve body earned a high rating for sludge deposits, particularly when considering the elevated heat and shifting frequency. Signature Series Multi-Vehicle Synthetic ATF demonstrated excellent resistance to extreme heat and sludge formation.

Transmission Sump Pan & Suction Screen



Note: Transmission pan is manufactured to be black in color.



Rating	
Sump Pan Sludge Deposits	9.25
%, Screen Clogging	< 5%

The transmission sump pan earned a high rating of 9.25. The suction screen demonstrated minimal clogging, earning a rating of less than 5 percent. Results confirm the effectiveness of the transmission fluid in resisting extreme heat, sludge and wear.

Clutch Plates (Gears 2 & 4)



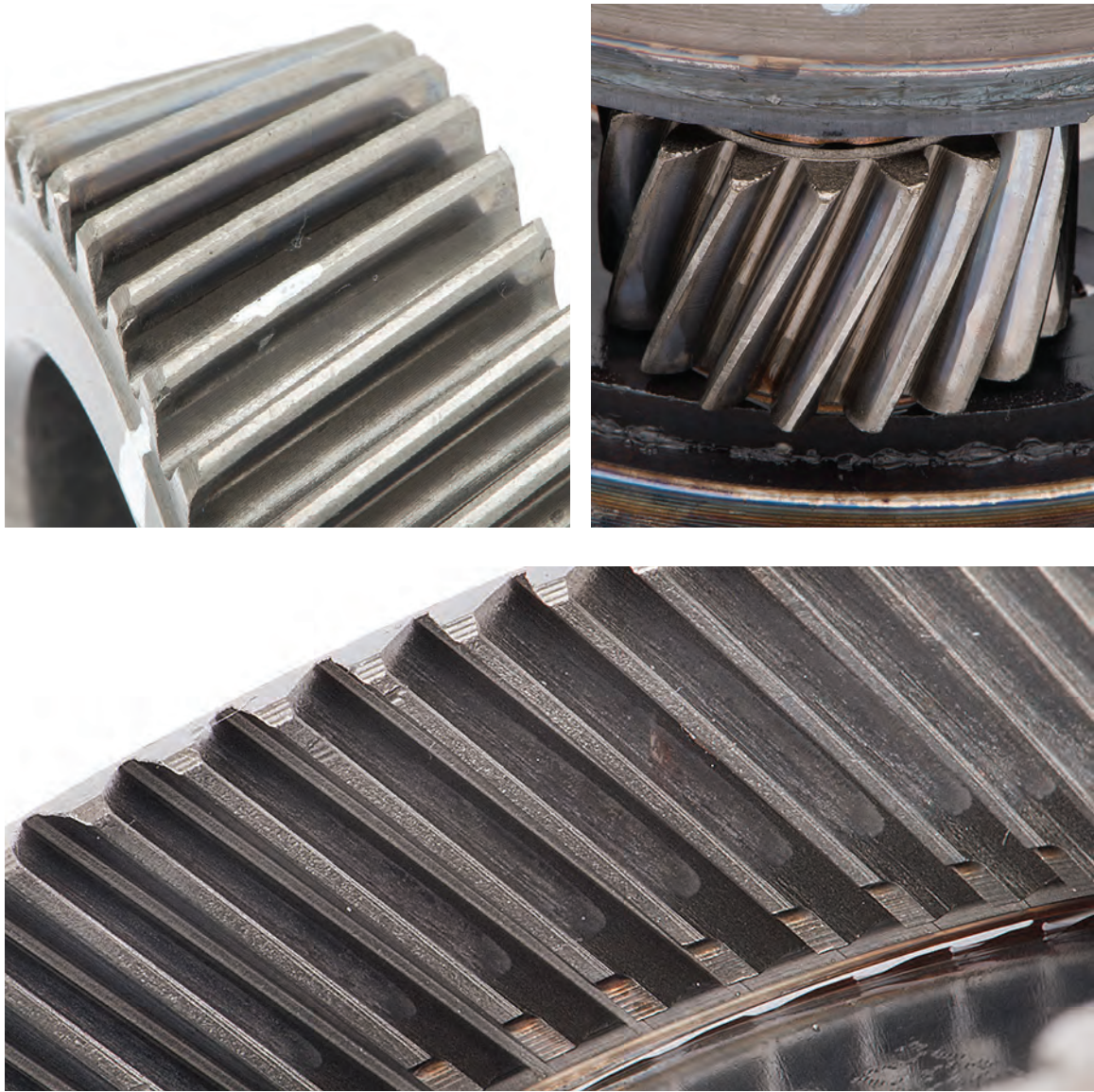
Manufacturer's stamp still visible.

Rating	
Discoloration	Trace
Deterioration/Wear	Good

Clutch packs are used to control movement of the planetary gear sets. The pack consists of alternate clutch plates lined with friction material and bare steel plates. Hydraulic pressure activates the clutch pack, squeezing the plates together to enable gear shifts. The process causes the clutch plates to bear friction repeatedly, inviting wear.

The clutch plates demonstrated only trace discoloration from heat. The manufacturer's stamping is still visible on the friction material despite it being a wear surface. In addition, the clutch plates earned the highest rating possible ("good") for deterioration/wear. Signature Series Multi-Vehicle Synthetic ATF prevented clutch glazing, ensuring excellent shift quality and strong protection for 12,891 hours (183,705 miles).

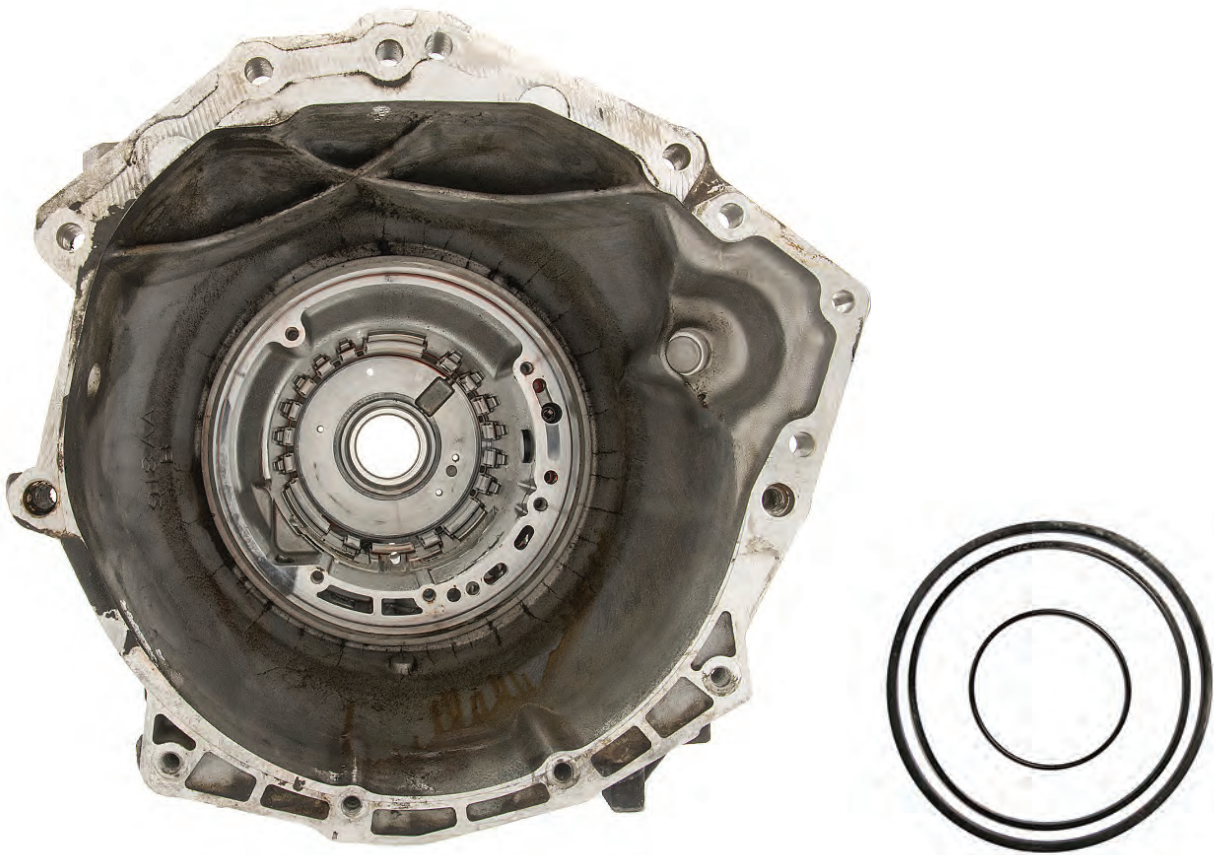
Planet, Sun & Ring Gears



Rating	
Planet Gear	Trace/Light
Sun Gear	Trace/Light
Ring Gear	Trace

The frequent shifts and demanding driving conditions common to taxi applications create the opportunity for excessive transmission gear wear. The planet and sun gears contained only “trace/light” wear, while the ring gear demonstrated only “trace” wear. Results indicate Signature Series Multi-Vehicle Synthetic ATF maintained its protective properties and provided a high level of wear protection in one of the most severe environments possible.

Transmission Case & Seals



	Rating
Transmission Case Sludge Deposits	9.8

Seals	Rating
Condition	Good
Softness	None
Lightness/Firmness	None
Firmness	None
Hardness	None
Brittleness	None
Cracking	None
Discoloration	None

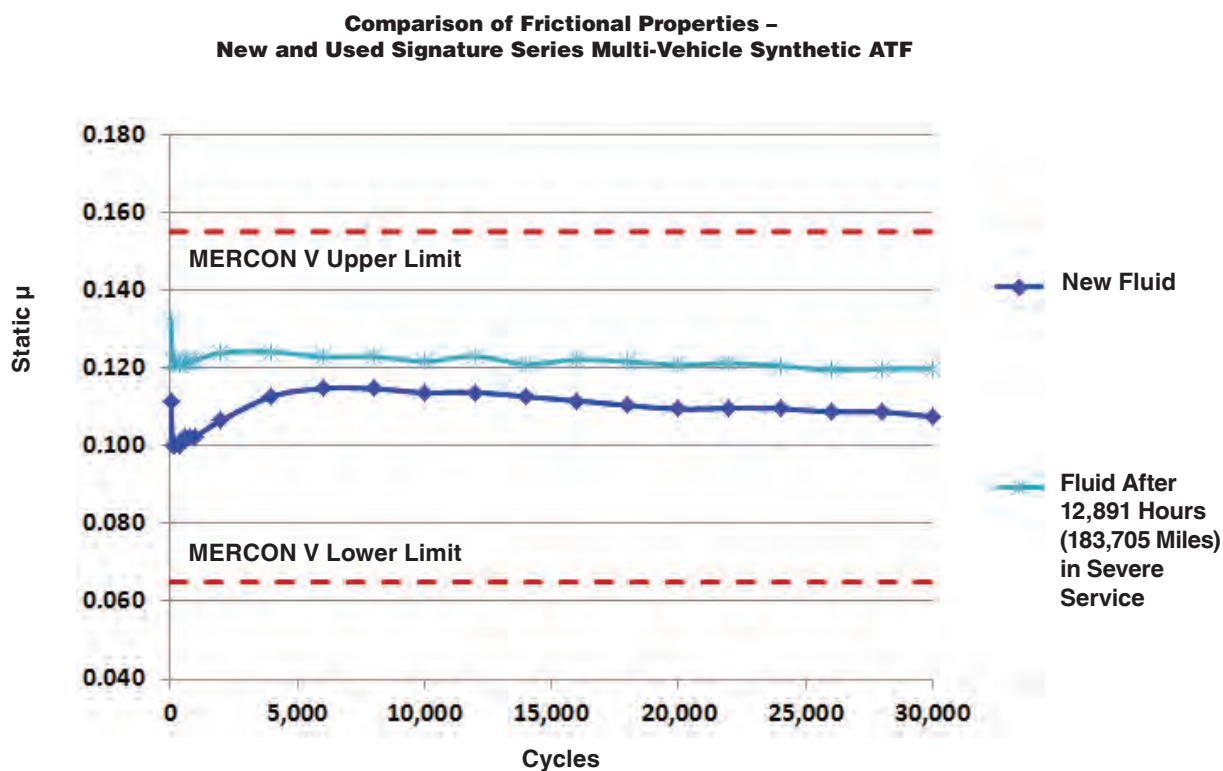
The transmission case was clean and virtually free of sludge. All transmission seals were found to be in “good” condition (the highest rating), with no cracking, discoloration or other stress detected. Results demonstrate Signature Series Multi-Vehicle ATF’s ability to protect seals exposed to high heat and severe-service operating conditions, providing long-term leak protection.

Used Transmission Fluid Analysis

After 12,891 hours (183,705 miles) in use, samples of the transmission fluid were subjected to laboratory bench testing for additional proof of performance.

Friction Durability of Used Fluid

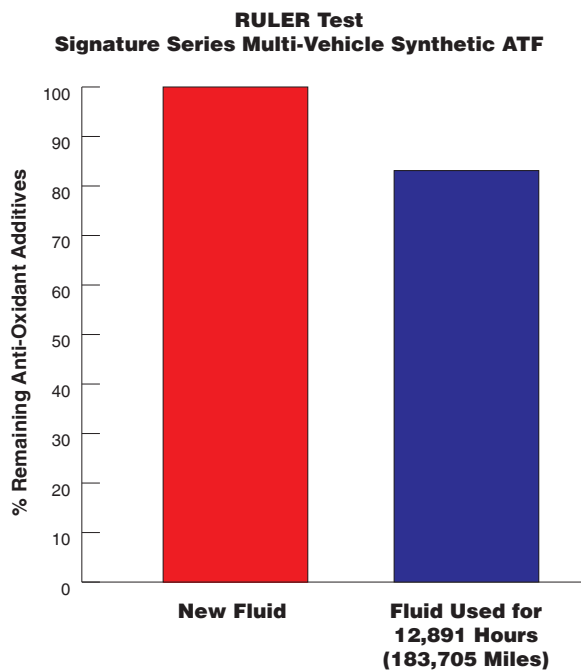
The transmission fluid's frictional properties are critical to proper operation of clutch packs. Over time, fluids exposed to extreme heat can fail to provide the correct frictional properties, resulting in clutch glazing, slipping, shudder, hard shifts and excessive wear. To determine the friction durability of Signature Series Multi-Vehicle Synthetic ATF in severe service, used fluid was analyzed with the SAE #2 Friction Test Machine using Borg Warner SD1777 friction plates specified in the Ford MERCON® V transmission fluid specification. (Chrysler maintains the friction material used in its ATF+4® transmission fluid specification as proprietary, thus it could not be obtained for the test.) The test subjected clutch packs to 30,000 cycles, during which the clutch engagement stops a spinning mass. Torque and time are measured, which provides the data required to determine the fluid's frictional properties. Results were compared to new fluid to determine any reduction. Ford MERCON V upper and lower limits are included as benchmarks.



Signature Series Multi-Vehicle Synthetic ATF used for 12,891 hours (183,705 miles) in severe service demonstrated frictional properties similar to new fluid. Results indicate the fluid excelled in maintaining its frictional properties and provided superior shift quality throughout the entire field study despite the severe operating conditions.

Remaining Useful Life Evaluation Routine (RULER) Test

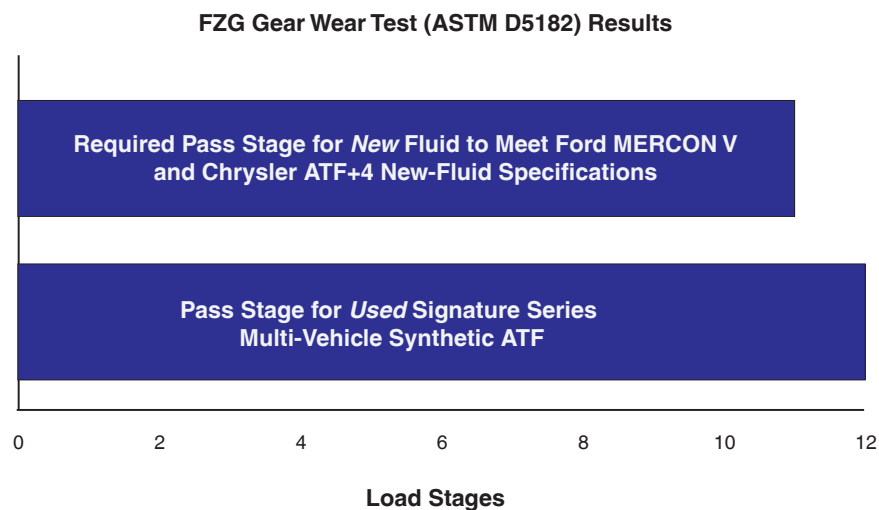
The Remaining Useful Life Evaluation Routine (RULER) Test measures the concentration of anti-oxidant additives remaining in the lubricant. As oil degrades over time, additives deplete, resulting in a corresponding decrease in the RULER value. The RULER Test compares the antioxidant concentration of used oil to the antioxidant concentration of new oil.



After 12,891 hours (183,705 miles), Signature Series Multi-Vehicle Synthetic ATF contained 83 percent of its original oxidation inhibitors. Results confirm the fluid's ability to provide reserve protection in transmissions that experience severe operating conditions.

FZG Gear Wear Test (ASTM D5182)

The FZG Gear Wear Test is designed to assess a lubricating fluid's ability to resist gear tooth scuffing. To simulate operating conditions, a machine operates at 1,450 rpm through up to 12 progressive stages that increase in load every 15 minutes. In accordance with the Chrysler ATF+4 and Ford MERCON V specifications, the test was conducted at 150°C. After each load stage, the gear teeth were inspected for scuffing and weighed to record any weight loss. Both new-lubricant specifications require a stage 11 pass.

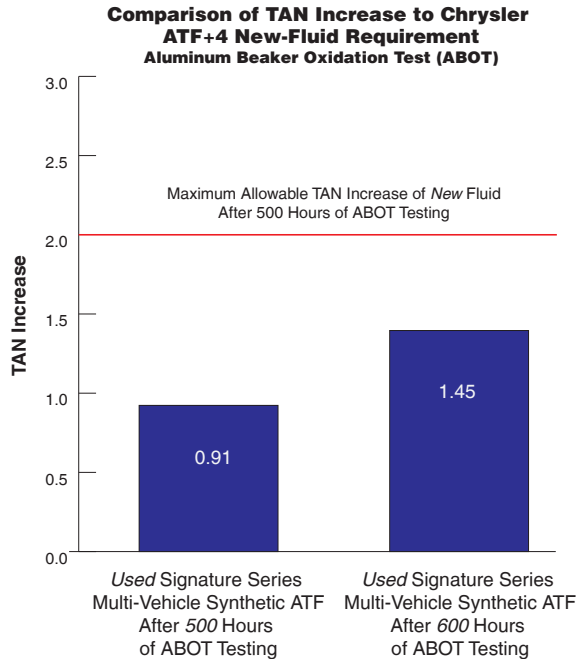


Signature Series Multi-Vehicle Synthetic ATF used for 12,891 hours (183,705 miles) passed all 12 load stages, with no noticeable difference in wear protection between new and used fluid. Results confirm the superior wear protection provided by the lubricant in severe operating conditions.

Comparison of Used Fluid to New-Fluid Specifications

Many original equipment manufacturers (OEMs) publish specifications that new, unused transmission fluids must meet to be used in the OEMs' equipment. For example, to meet the Chrysler ATF+4 specification, transmission fluid subjected to the Aluminum Beaker Oxidation Test (ABOT) for 500 hours must demonstrate a total acid number (TAN) increase of two or less. To meet the Ford MERCON V new-fluid specification (included for additional comparison), the fluid's TAN increase after 300 hours of ABOT testing must remain below 3.5. Excessive increases in TAN can be an indicator the fluid has reached its condemnation limit.

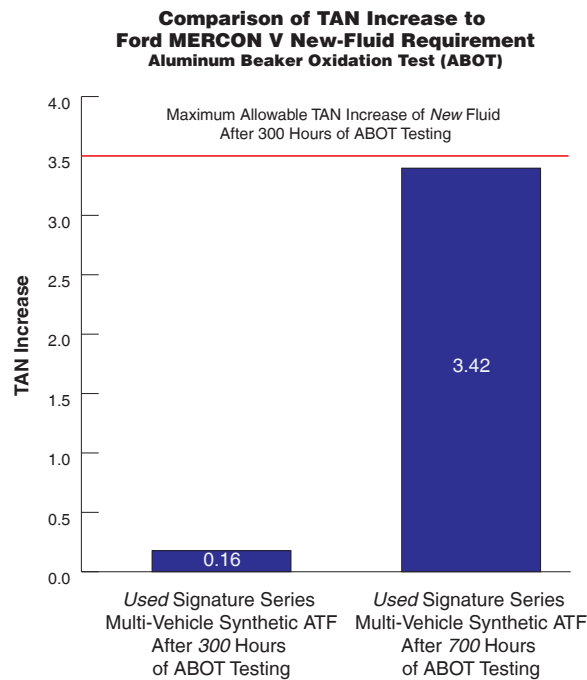
The properties of Signature Series Synthetic ATF that had been used for 12,891 hours (183,705 miles) in severe service were compared to new-fluid specifications for TAN and viscosity increase. Because the amount of fluid available for testing was limited, percent viscosity increase was not determined beyond 300 hours of ABOT testing.



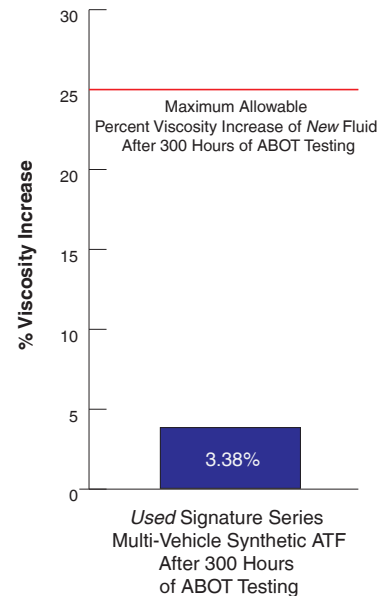
Following 500 hours of ABOT testing, the TAN of used Signature Series Multi-Vehicle Synthetic ATF increased by .91, remaining below the maximum allowable to meet the Chrysler ATF+4 new-fluid specification. Even after continuing testing to 600 hours, the lubricant's TAN increase met the requirement for new fluid.

Comparing to the Ford MERCON V specification produced similar results. The lubricant's TAN increase after 300 hours of ABOT testing (0.16) remained below the maximum allowable. After more than doubling the required hours of testing to 700 hours, the lubricant's TAN increase (3.42) still remained below the threshold. The lubricant's viscosity increase after 300 hours (3.38 percent) was also below the maximum allowable percent increase to meet the Ford MERCON V new-fluid specification.

Even after 12,891 hours (183,705 miles) of use in severe service, the lubricant surpassed the TAN requirements for new fluid to meet the Chrysler ATF+4 and Ford MERCON V requirements. Signature Series Multi-Vehicle Synthetic ATF continued providing a high level of protection throughout the entire drain interval and was suitable for continued use.



Comparison of Viscosity Increase to Ford MERCON V New-Fluid Requirement
Aluminum Beaker Oxidation Test (ABOT)



PART TWO

ENGINE RESULTS

As noted earlier, oil change intervals were determined in hours during the field study. The average oil change interval for the Dodge Charger was 1,005 hours (14,619 miles). The Environmental Protection Agency's (EPA) Federal Test Procedure (FTP) Driving Schedule and Highway Fuel Economy Test (HWFET)¹ were used to convert the Charger's 1,005 hours of operating time between oil changes to total miles likely to be accumulated by an average motorist. Results are shown below.

Dodge Charger Hourly Oil Change Interval Converted to Miles

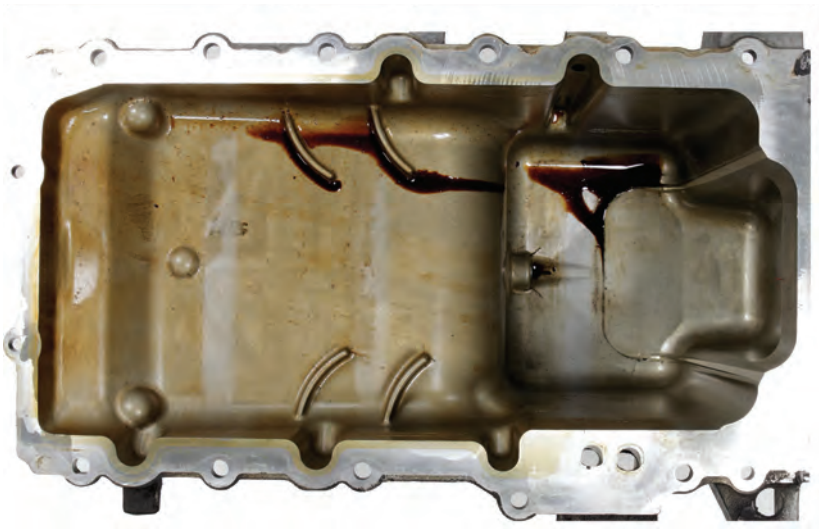
Hours on Oil		City Driving (21.2 mph/avg.) ¹	Highway Driving (48.3 mph/avg.) ¹
1,005	=	21,306 miles	48,542 miles

The Dodge Charger averaged 14.6 mph throughout the field study, increasing severity compared to the EPA city-driving definition. Although the vehicle carries a recommended oil change interval of 6,000 miles/6 months, whichever comes first, its oil change interval was more than doubled.

¹ http://www.fueleconomy.gov/feg/fe_test_schedules.shtml

Component Analysis & Ratings

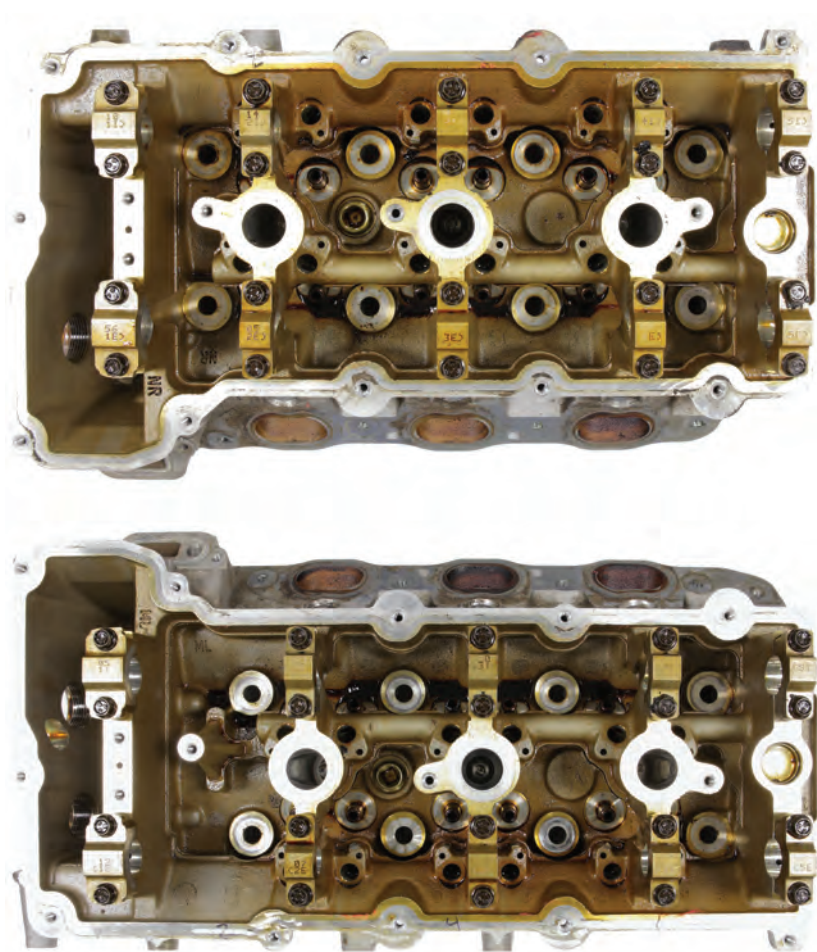
Oil Pan & Pickup Tube



	Rating
Oil Pan Sludge Deposits	9.63
Oil Pan Varnish Deposits	9.00
% Clogging, Oil Screen	1

Motor oils incapable of withstanding extreme heat can allow excessive sludge to accumulate in the oil pan. Sludge can then clog the oil screen on the oil pickup tube, starving the engine of oil and leading to catastrophic failure. Signature Series Synthetic Motor Oil demonstrated superior ability to guard against the formation of sludge, with the oil pan earning a high rating. The oil screen demonstrated 1 percent clogging, proving the oil's ability to provide increased protection in severe service.

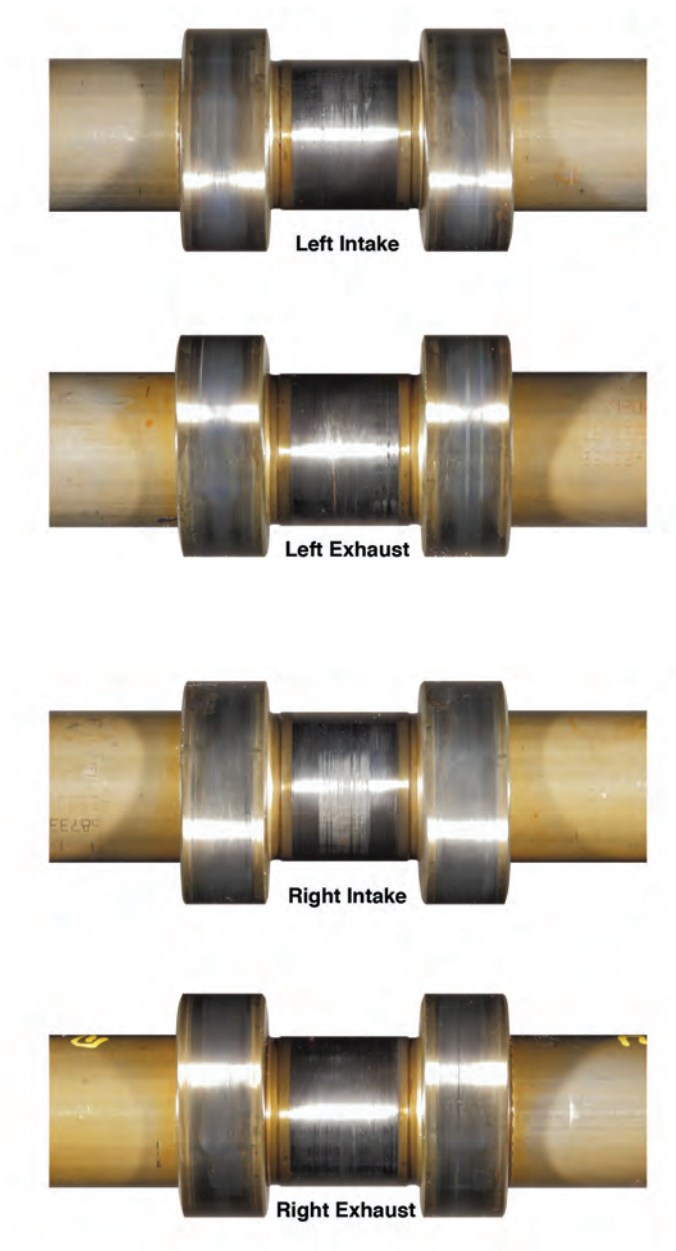
Cylinder Heads



	Rating
Right Valve Deck Sludge Deposits	9.63
Left Valve Deck Sludge Deposits	9.63

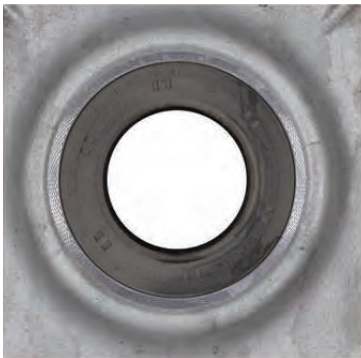
Like the oil pan, the cylinder heads are prone to accumulating sludge if using motor oils with poor thermal stability. Following 7,033 hours (102,582 miles), the cylinder heads contained no black sludge, earned high ratings and demonstrated superior cleanliness despite the challenging operating conditions. Signature Series Synthetic Motor Oil exhibited outstanding thermal stability.

Camshaft Lobes



Excessive sludge formation can cause oil starvation, particularly in the upper valvetrain due to narrow oil passages and the distance the oil must travel. The cam lobes exhibited very little wear, with no visible flaking or spalling. Signature Series Synthetic Motor Oil demonstrated excellent wear protection in addition to sludge resistance throughout 7,033 hours (102,582 miles).

Front Cover & Seal



Front Cover	Rating
Sludge Deposits	9.84
Varnish Deposits	9.60

Seals	Rating
Hardening	None
Cracking	None
Softening	None
Blistering	None
Varnishing	Very Light
Chunking	None
Carboning	Moderate
Wear	None
Grooving	None
Leakage	None

The front cover, also referred to as the timing chain cover, is clean and virtually free of sludge or varnish. The front cover seal remained in excellent condition throughout the study, with only very light varnish and no wear, leakage or other distress. Signature Series Synthetic Motor Oil demonstrated excellent seal compatibility and protection.

Conclusion

Field testing proves that AMSOIL Signature Series Multi-Vehicle Synthetic ATF and AMSOIL Signature Series Synthetic Motor Oil provide superior protection against sludge and wear for extended drain intervals in severe service. Components from a Las Vegas cab's transmission revealed minimal distress despite accumulating 12,891 hours (183,705 miles) of severe service on a single fluid change. The valve body earned a high rating for sludge deposits while the clutch plates revealed no discoloration and little wear. Used transmission fluid analysis revealed the fluid still met TAN requirements of new fluid for the Chrysler ATF+4 and Ford MERCON V specifications. Used fluid also demonstrated wear protection in the FZG Gear Wear Test identical to new fluid, providing additional proof of performance.

Engine parts having accumulated 7,033 hours of service (102,582 miles) demonstrated similar results, with the cylinder heads, oil pan and front cover clean and virtually free of sludge. The motor oil provided superior protection for seals and cam lobes, demonstrating its ability to safely extend drain intervals in severe service.

The performance of each fluid in notoriously severe applications operating in challenging conditions indicates their capability to protect in the harshest environments faced by fleet vehicles, heavy-duty pickups, work trucks and personal passenger cars. Results confirm the fluids' ability to provide reserve protection beyond the severe-service recommendations of original equipment manufacturers (OEMs).



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Referral # _____

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Overview

Few applications place more stress on lubricants than taxi cabs, particularly those operating in the desert heat of Las Vegas, Nev. The combination of excessive idling, stop-and-go driving and high ambient temperatures creates the ideal scenario for lubricant failure, resulting in sludge formation and catastrophic component failure.

Fleet vehicles, heavy-duty pickups, work trucks and other commercial applications operate under severe service. In addition, drain intervals are getting longer. For engines and transmissions to last as designed and achieve maximum performance, lubricants today must protect against elevated heat and its associated problems for longer periods of service.

Objective

Demonstrate that AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid and Signature Series Synthetic Motor Oil protect against extreme heat and sludge formation during extended drain intervals in vehicles routinely operated in severe conditions. Further demonstrate that the lubricants meet the increased performance demands of modern fleet, commercial and other professional vehicles.

Method

In conducting this field study, AMSOIL sought a test partner with vehicles used in the most demanding conditions possible. A Las Vegas taxi company was selected due to the challenges inherent to taxi applications and the extreme desert heat, which presented a worst-case scenario that further challenged the lubricants. In fact, the taxi company had been experiencing rampant engine failure using synthetic blend motor oil recommended for API SN/ILSAC GF-5 service requirements and changed every 5,000 miles. Engine failures occurred predominantly during hot summer months due to excess sludge clogging the oil pickup tubes and starving the engines of oil. The severity of service also required frequent transmission fluid changes (every 20,000 miles).

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Transmission: AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid

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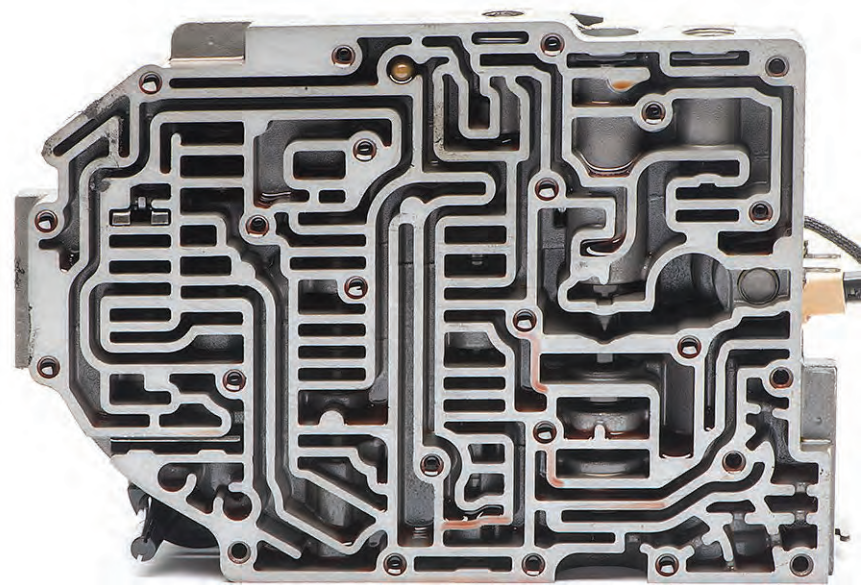
PART ONE

TRANSMISSION RESULTS

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Valve Body



Rating	
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Transmission Sump Pan & Suction Screen



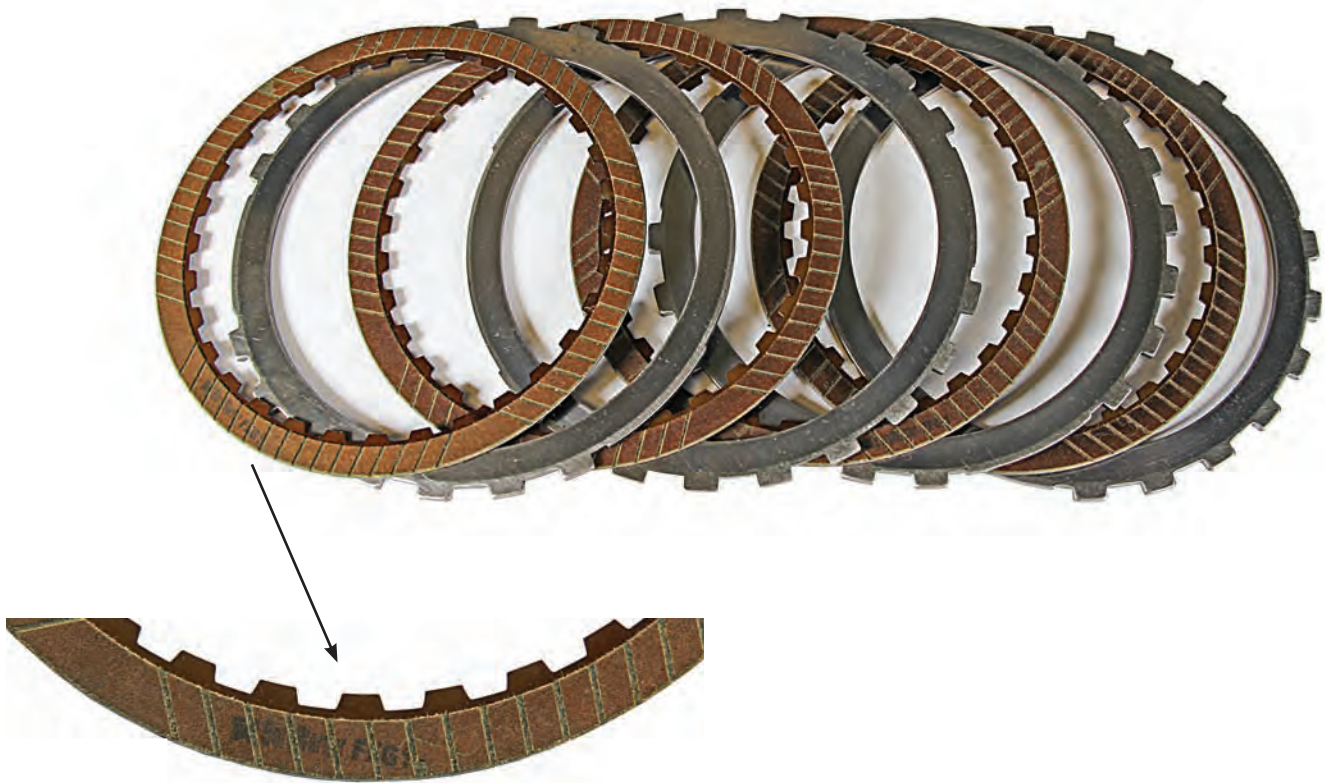
Note: Transmission pan is manufactured to be black in color.



Rating	
Sump Pan Sludge Deposits	9.25
%, Screen Clogging	< 5%

The transmission sump pan earned a high rating of 9.25. The suction screen demonstrated minimal clogging, earning a rating of less than 5 percent. Results confirm the effectiveness of the transmission fluid in resisting extreme heat, sludge and wear.

Clutch Plates (Gears 2 & 4)



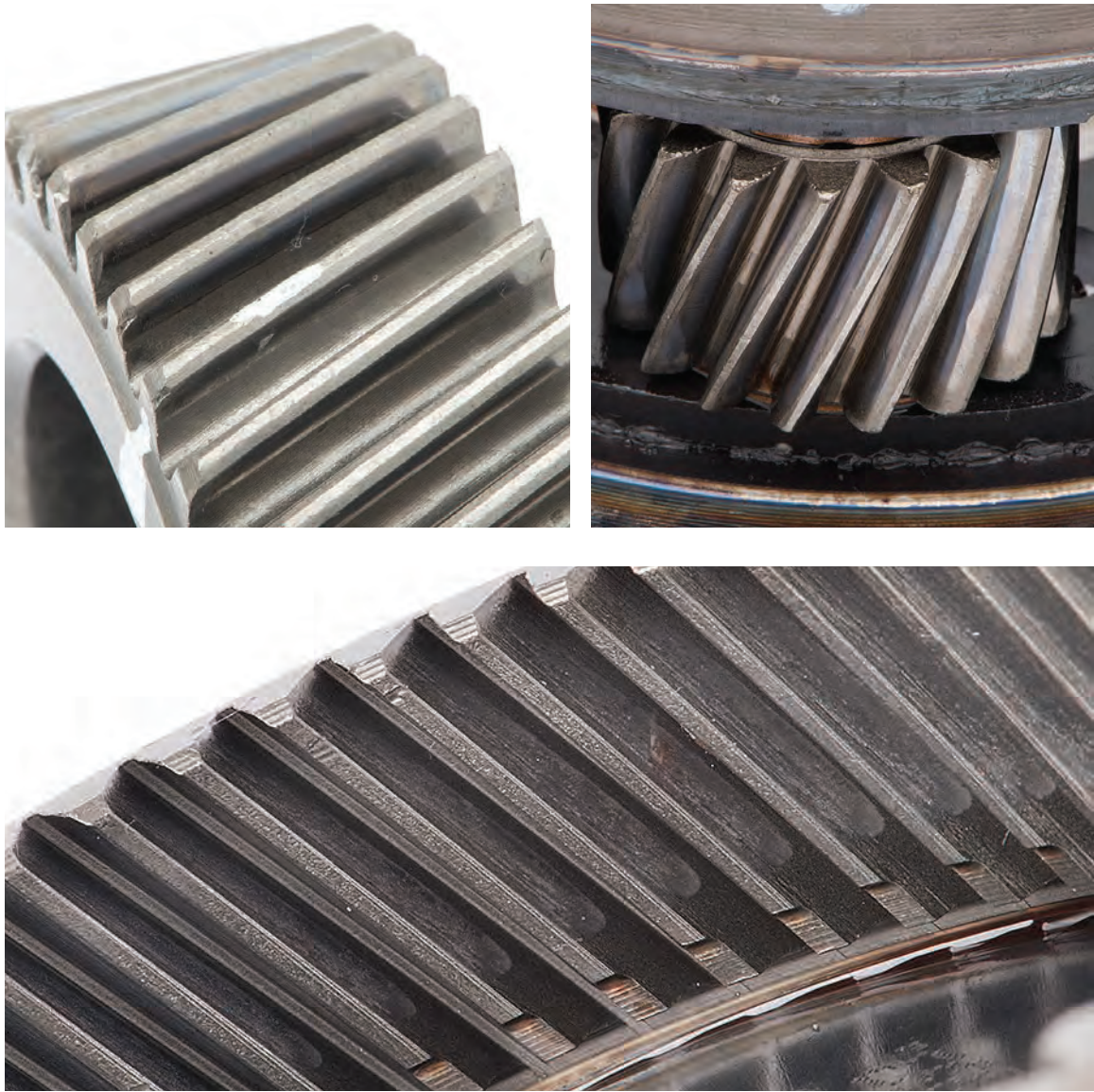
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Rating	
Discoloration	Trace
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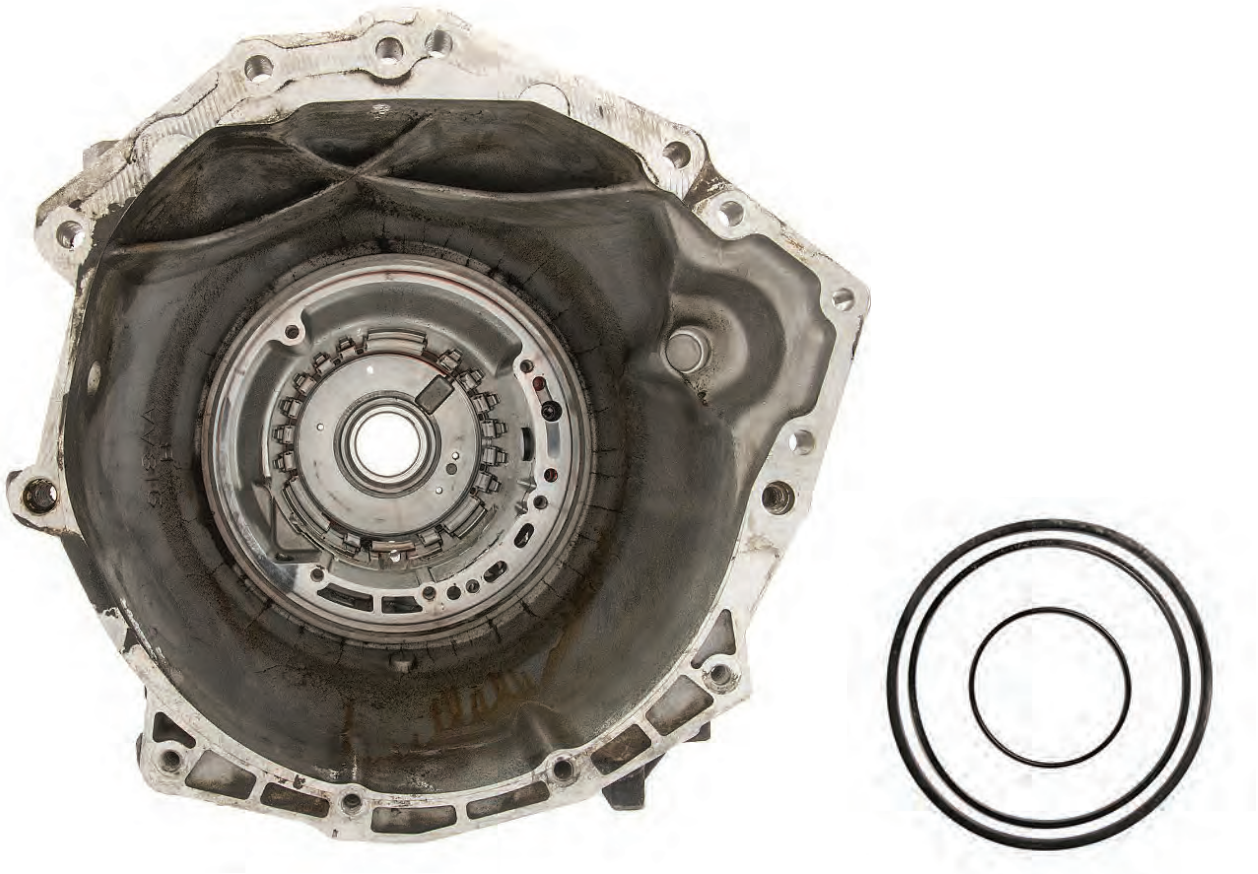
Planet, Sun & Ring Gears



	Rating
Planet Gear	Trace/Light
Sun Gear	Trace/Light
Ring Gear	Trace

The frequent shifts and demanding driving conditions common to taxi applications create the opportunity for excessive transmission gear wear. The planet and sun gears contained only “trace/light” wear, while the ring gear demonstrated only “trace” wear. Results indicate Signature Series Multi-Vehicle Synthetic ATF maintained its protective properties and provided a high level of wear protection in one of the most severe environments possible.

Transmission Case & Seals



	Rating
Transmission Case Sludge Deposits	9.8

Seals	Rating
Condition	Good
Softness	None
Lightness/Firmness	None
Firmness	None
Hardness	None
Brittleness	None
Cracking	None
Discoloration	None

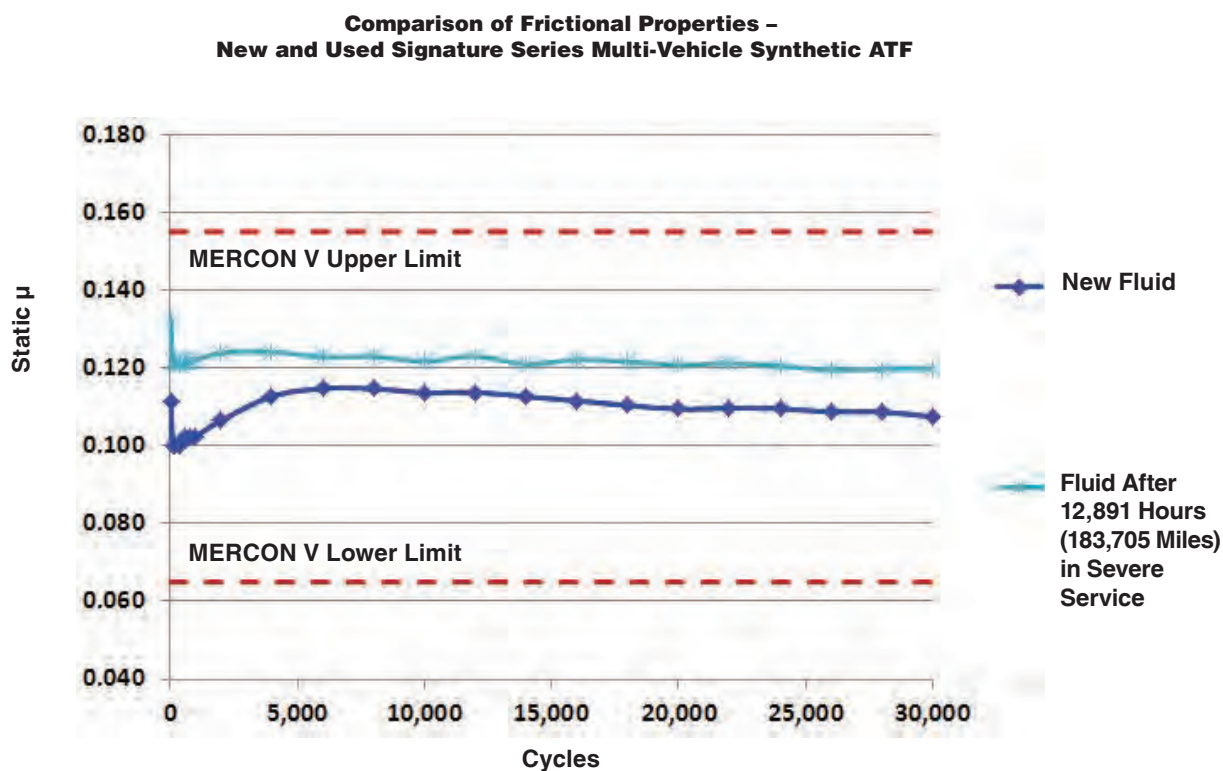
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Used Transmission Fluid Analysis

After 12,891 hours (183,705 miles) in use, samples of the transmission fluid were subjected to laboratory bench testing for additional proof of performance.

Friction Durability of Used Fluid

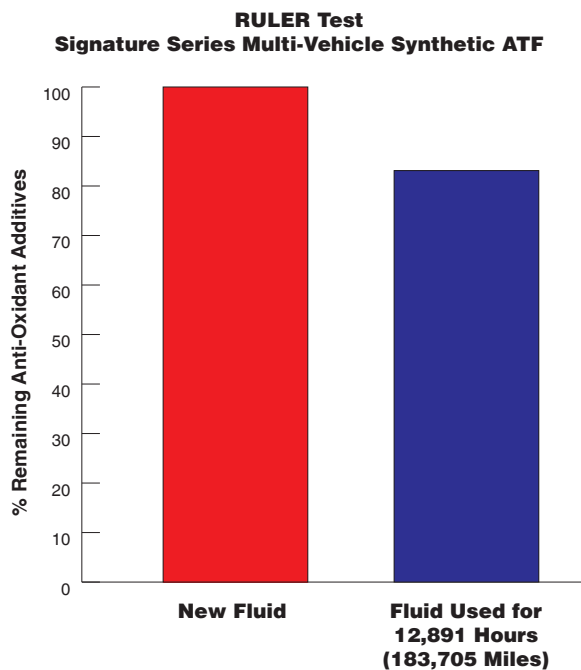
The transmission fluid's frictional properties are critical to proper operation of clutch packs. Over time, fluids exposed to extreme heat can fail to provide the correct frictional properties, resulting in clutch glazing, slipping, shudder, hard shifts and excessive wear. To determine the friction durability of Signature Series Multi-Vehicle Synthetic ATF in severe service, used fluid was analyzed with the SAE #2 Friction Test Machine using Borg Warner SD1777 friction plates specified in the Ford MERCON® V transmission fluid specification. (Chrysler maintains the friction material used in its ATF+4® transmission fluid specification as proprietary, thus it could not be obtained for the test.) The test subjected clutch packs to 30,000 cycles, during which the clutch engagement stops a spinning mass. Torque and time are measured, which provides the data required to determine the fluid's frictional properties. Results were compared to new fluid to determine any reduction. Ford MERCON V upper and lower limits are included as benchmarks.



Signature Series Multi-Vehicle Synthetic ATF used for 12,891 hours (183,705 miles) in severe service demonstrated frictional properties similar to new fluid. Results indicate the fluid excelled in maintaining its frictional properties and provided superior shift quality throughout the entire field study despite the severe operating conditions.

Remaining Useful Life Evaluation Routine (RULER) Test

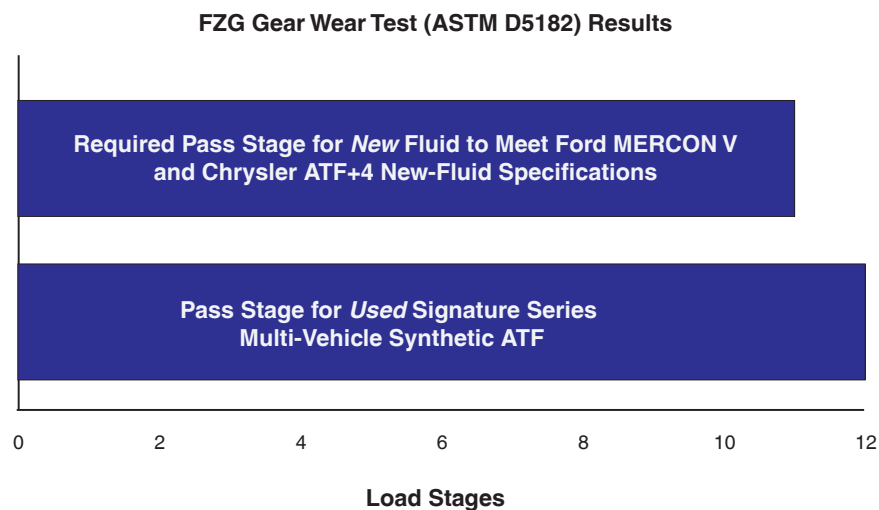
The Remaining Useful Life Evaluation Routine (RULER) Test measures the concentration of anti-oxidant additives remaining in the lubricant. As oil degrades over time, additives deplete, resulting in a corresponding decrease in the RULER value. The RULER Test compares the antioxidant concentration of used oil to the antioxidant concentration of new oil.



After 12,891 hours (183,705 miles), Signature Series Multi-Vehicle Synthetic ATF contained 83 percent of its original oxidation inhibitors. Results confirm the fluid's ability to provide reserve protection in transmissions that experience severe operating conditions.

FZG Gear Wear Test (ASTM D5182)

The FZG Gear Wear Test is designed to assess a lubricating fluid's ability to resist gear tooth scuffing. To simulate operating conditions, a machine operates at 1,450 rpm through up to 12 progressive stages that increase in load every 15 minutes. In accordance with the Chrysler ATF+4 and Ford MERCON V specifications, the test was conducted at 150°C. After each load stage, the gear teeth were inspected for scuffing and weighed to record any weight loss. Both new-lubricant specifications require a stage 11 pass.

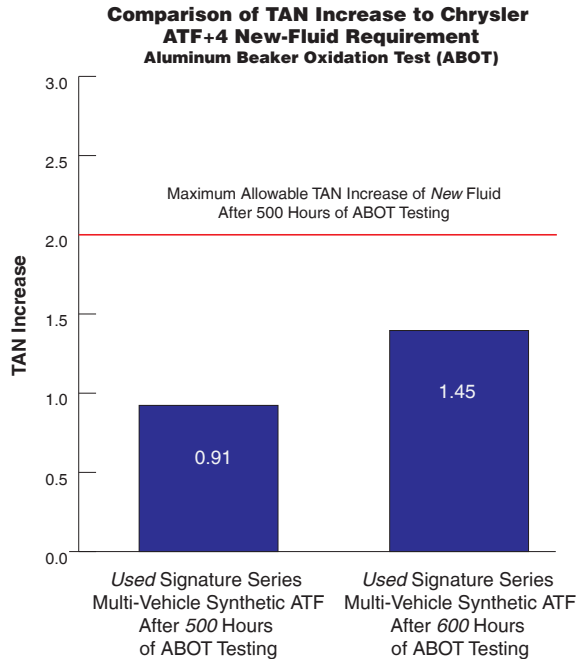


Signature Series Multi-Vehicle Synthetic ATF used for 12,891 hours (183,705 miles) passed all 12 load stages, with no noticeable difference in wear protection between new and used fluid. Results confirm the superior wear protection provided by the lubricant in severe operating conditions.

Comparison of Used Fluid to New-Fluid Specifications

Many original equipment manufacturers (OEMs) publish specifications that new, unused transmission fluids must meet to be used in the OEMs' equipment. For example, to meet the Chrysler ATF+4 specification, transmission fluid subjected to the Aluminum Beaker Oxidation Test (ABOT) for 500 hours must demonstrate a total acid number (TAN) increase of two or less. To meet the Ford MERCON V new-fluid specification (included for additional comparison), the fluid's TAN increase after 300 hours of ABOT testing must remain below 3.5. Excessive increases in TAN can be an indicator the fluid has reached its condemnation limit.

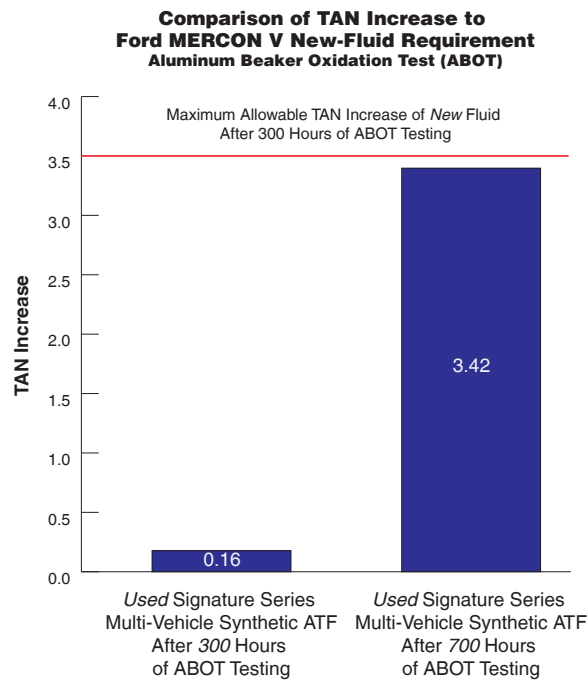
The properties of Signature Series Synthetic ATF that had been used for 12,891 hours (183,705 miles) in severe service were compared to new-fluid specifications for TAN and viscosity increase. Because the amount of fluid available for testing was limited, percent viscosity increase was not determined beyond 300 hours of ABOT testing.



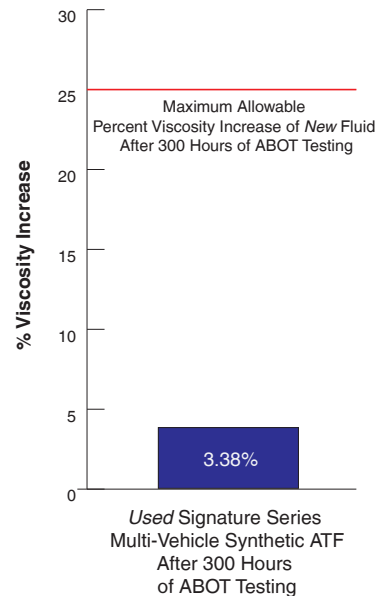
Following 500 hours of ABOT testing, the TAN of used Signature Series Multi-Vehicle Synthetic ATF increased by .91, remaining below the maximum allowable to meet the Chrysler ATF+4 new-fluid specification. Even after continuing testing to 600 hours, the lubricant's TAN increase met the requirement for new fluid.

Comparing to the Ford MERCON V specification produced similar results. The lubricant's TAN increase after 300 hours of ABOT testing (0.16) remained below the maximum allowable. After more than doubling the required hours of testing to 700 hours, the lubricant's TAN increase (3.42) still remained below the threshold. The lubricant's viscosity increase after 300 hours (3.38 percent) was also below the maximum allowable percent increase to meet the Ford MERCON V new-fluid specification.

Even after 12,891 hours (183,705 miles) of use in severe service, the lubricant surpassed the TAN requirements for new fluid to meet the Chrysler ATF+4 and Ford MERCON V requirements. Signature Series Multi-Vehicle Synthetic ATF continued providing a high level of protection throughout the entire drain interval and was suitable for continued use.



Comparison of Viscosity Increase to Ford MERCON V New-Fluid Requirement
Aluminum Beaker Oxidation Test (ABOT)



PART TWO

ENGINE RESULTS

As noted earlier, oil change intervals were determined in hours during the field study. The average oil change interval for the Dodge Charger was 1,005 hours (14,619 miles). The Environmental Protection Agency's (EPA) Federal Test Procedure (FTP) Driving Schedule and Highway Fuel Economy Test (HWFET)¹ were used to convert the Charger's 1,005 hours of operating time between oil changes to total miles likely to be accumulated by an average motorist. Results are shown below.

Dodge Charger Hourly Oil Change Interval Converted to Miles

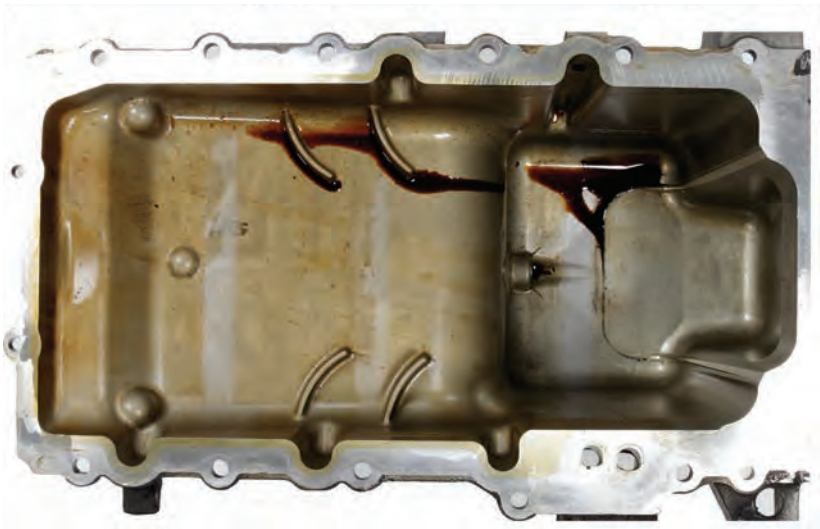
Hours on Oil		City Driving (21.2 mph/avg.) ¹	Highway Driving (48.3 mph/avg.) ¹
1,005	=	21,306 miles	48,542 miles

The Dodge Charger averaged 14.6 mph throughout the field study, increasing severity compared to the EPA city-driving definition. Although the vehicle carries a recommended oil change interval of 6,000 miles/6 months, whichever comes first, its oil change interval was more than doubled.

¹ http://www.fueleconomy.gov/feg/fe_test_schedules.shtml

Component Analysis & Ratings

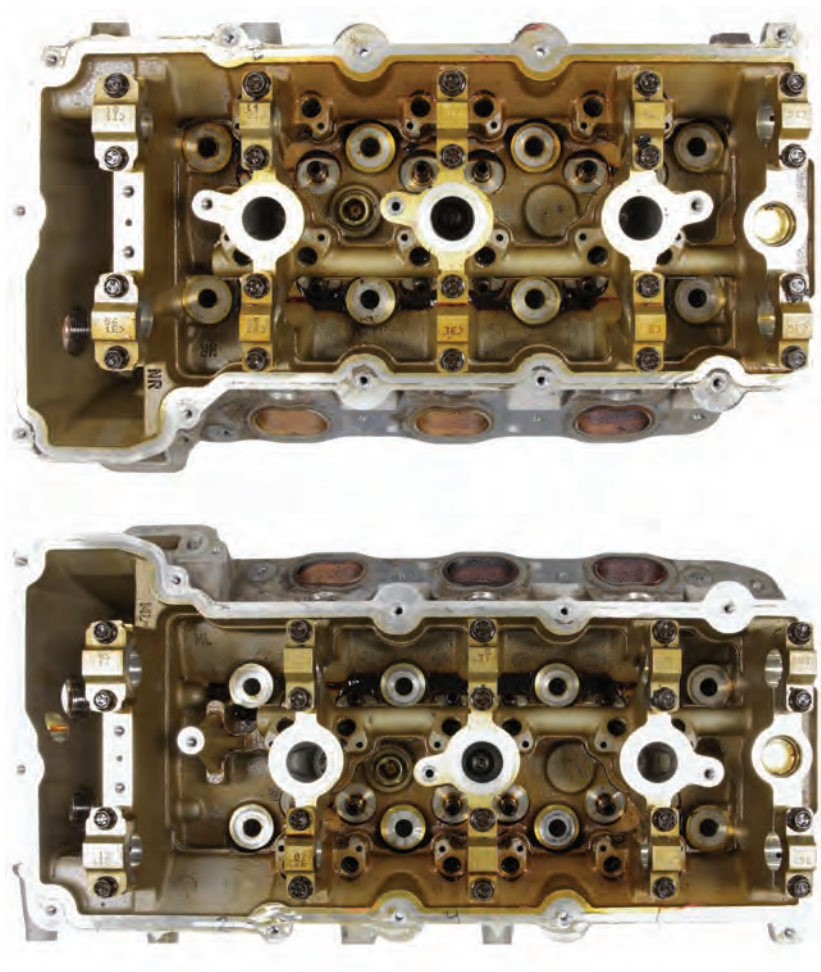
Oil Pan & Pickup Tube



	Rating
Oil Pan Sludge Deposits	9.63
Oil Pan Varnish Deposits	9.00
% Clogging, Oil Screen	1

Motor oils incapable of withstanding extreme heat can allow excessive sludge to accumulate in the oil pan. Sludge can then clog the oil screen on the oil pickup tube, starving the engine of oil and leading to catastrophic failure. Signature Series Synthetic Motor Oil demonstrated superior ability to guard against the formation of sludge, with the oil pan earning a high rating. The oil screen demonstrated 1 percent clogging, proving the oil's ability to provide increased protection in severe service.

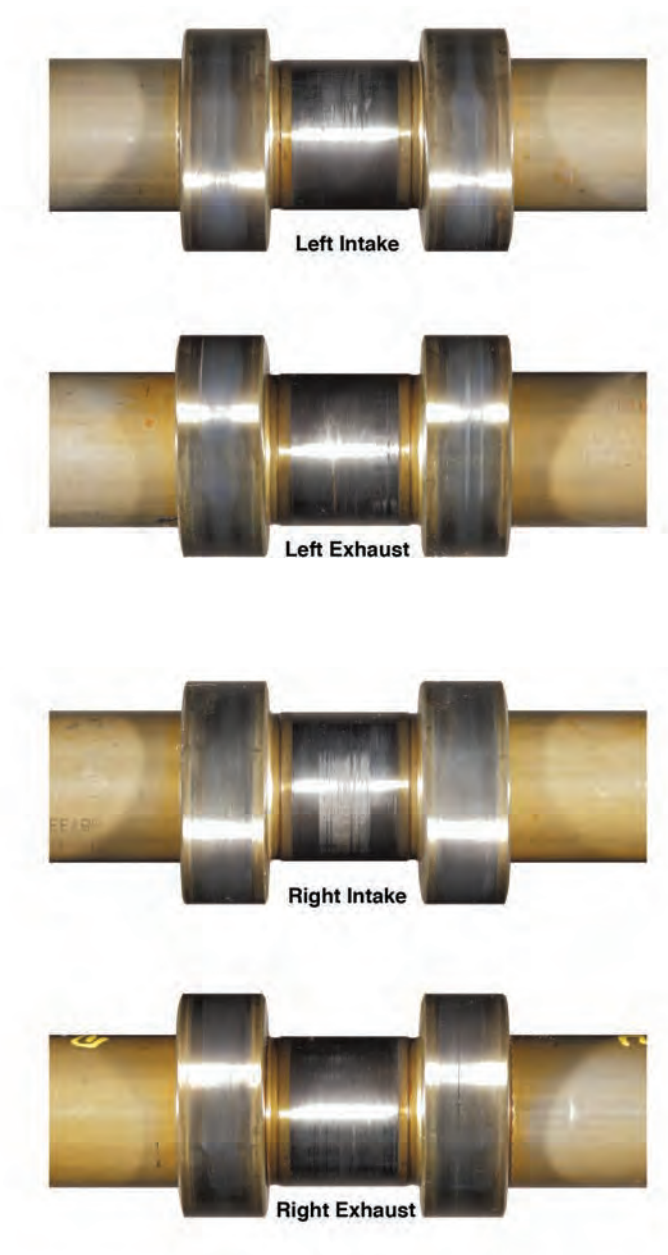
Cylinder Heads



	Rating
Right Valve Deck Sludge Deposits	9.63
Left Valve Deck Sludge Deposits	9.63

Like the oil pan, the cylinder heads are prone to accumulating sludge if using motor oils with poor thermal stability. Following 7,033 hours (102,582 miles), the cylinder heads contained no black sludge, earned high ratings and demonstrated superior cleanliness despite the challenging operating conditions. Signature Series Synthetic Motor Oil exhibited outstanding thermal stability.

Camshaft Lobes



Excessive sludge formation can cause oil starvation, particularly in the upper valvetrain due to narrow oil passages and the distance the oil must travel. The cam lobes exhibited very little wear, with no visible flaking or spalling. Signature Series Synthetic Motor Oil demonstrated excellent wear protection in addition to sludge resistance throughout 7,033 hours (102,582 miles).

Front Cover & Seal



Front Cover	Rating
Sludge Deposits	9.84
Varnish Deposits	9.60

Seals	Rating
Hardening	None
Cracking	None
Softening	None
Blistering	None
Varnishing	Very Light
Chunking	None
Carboning	Moderate
Wear	None
Grooving	None
Leakage	None

The front cover, also referred to as the timing chain cover, is clean and virtually free of sludge or varnish. The front cover seal remained in excellent condition throughout the study, with only very light varnish and no wear, leakage or other distress. Signature Series Synthetic Motor Oil demonstrated excellent seal compatibility and protection.

Conclusion

Field testing proves that AMSOIL Signature Series Multi-Vehicle Synthetic ATF and AMSOIL Signature Series Synthetic Motor Oil provide superior protection against sludge and wear for extended drain intervals in severe service. Components from a Las Vegas cab's transmission revealed minimal distress despite accumulating 12,891 hours (183,705 miles) of severe service on a single fluid change. The valve body earned a high rating for sludge deposits while the clutch plates revealed no discoloration and little wear. Used transmission fluid analysis revealed the fluid still met TAN requirements of new fluid for the Chrysler ATF+4 and Ford MERCON V specifications. Used fluid also demonstrated wear protection in the FZG Gear Wear Test identical to new fluid, providing additional proof of performance.

Engine parts having accumulated 7,033 hours of service (102,582 miles) demonstrated similar results, with the cylinder heads, oil pan and front cover clean and virtually free of sludge. The motor oil provided superior protection for seals and cam lobes, demonstrating its ability to safely extend drain intervals in severe service.

The performance of each fluid in notoriously severe applications operating in challenging conditions indicates their capability to protect in the harshest environments faced by fleet vehicles, heavy-duty pickups, work trucks and personal passenger cars. Results confirm the fluids' ability to provide reserve protection beyond the severe-service recommendations of original equipment manufacturers (OEMs).



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Las Vegas Taxi Cab Field Study

An evaluation of AMSOIL Signature Series Multi-Vehicle Synthetic ATF and Signature Series Synthetic Motor Oil operated under severe-service conditions for extended drain intervals.

Second Edition
Published April 2014



Editor's Note:

AMSOIL published the first edition of the *Las Vegas Taxi Cab Field Study* in April 2013. Results demonstrated the excellent performance of AMSOIL synthetic lubricants in severe-service commercial applications operating in the searing Las Vegas heat. The original transmission accumulated more than 102,000 miles on a single fluid change. To further test the capabilities of AMSOIL Signature Series Multi-Vehicle Synthetic Transmission Fluid, it was installed in another taxi that was operated for 12,891 hours (183,705 miles) – 3X original equipment manufacturer recommendations – on a single fluid change. Those results are presented here along with the engine results from the first edition of this study.

Overview

Few applications place more stress on lubricants than taxi cabs, particularly those operating in the desert heat of Las Vegas, Nev. The combination of excessive idling, stop-and-go driving and high ambient temperatures creates the ideal scenario for lubricant failure, resulting in sludge formation and catastrophic component failure.

Fleet vehicles, heavy-duty pickups, work trucks and other commercial applications operate under severe service. In addition, drain intervals are getting longer. For engines and transmissions to last as designed and achieve maximum performance, lubricants today must protect against elevated heat and its associated problems for longer periods of service.

Objective

Demonstrate that AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid and Signature Series Synthetic Motor Oil protect against extreme heat and sludge formation during extended drain intervals in vehicles routinely operated in severe conditions. Further demonstrate that the lubricants meet the increased performance demands of modern fleet, commercial and other professional vehicles.

Method

In conducting this field study, AMSOIL sought a test partner with vehicles used in the most demanding conditions possible. A Las Vegas taxi company was selected due to the challenges inherent to taxi applications and the extreme desert heat, which presented a worst-case scenario that further challenged the lubricants. In fact, the taxi company had been experiencing rampant engine failure using synthetic blend motor oil recommended for API SN/ILSAC GF-5 service requirements and changed every 5,000 miles. Engine failures occurred predominantly during hot summer months due to excess sludge clogging the oil pickup tubes and starving the engines of oil. The severity of service also required frequent transmission fluid changes (every 20,000 miles).

Signature Series Synthetic Automatic Transmission Fluid and Signature Series Synthetic Motor Oil were installed in six of the fleet's vehicles. The test vehicles were placed into service and operated within the fleet's service area of Las Vegas up to 24 consecutive hours each day, with the engines often shut down only during refueling or personnel changes. Excessive time idling combined with stop-and-go driving loaded with passengers and cargo characterized typical driving conditions. During summer months, ambient temperatures often exceeded 100°F, further increasing severity.

Motor oil in the test vehicles was scheduled to be changed at a minimum of 900-hour intervals. The actual motor oil change intervals for the engine reported in this study were 1,005 hours (approximately 15,000 miles). Transmission fluid was not changed in any of the vehicles.

Note: Oil change intervals were determined using hours rather than miles due to excessive idling and low-speed driving. In these conditions, hours of service provides a more accurate measure of the oil's service life. To illustrate the severity of service for the average motorist, 900 hours of total operating time is equivalent to 19,080 miles in city driving conditions and 43,470 miles in on-highway conditions.¹

Following testing, engine and transmission parts were rated for sludge, wear and other distress by an independent calibrated rater according to the criteria given in the appropriate Coordinating Research Council (CRC) manual. Parts were assigned a numeric rating on a descending scale, with 10 representing no distress and 0 representing catastrophic distress. Some parts were assigned a descriptive rating (e.g. "None", "Good", etc.) describing the level of distress. Results are divided into two parts, one for the transmission and the other for the engine.

Vehicles Selected for Teardown & Analysis

Engine

After accumulating 7,033 hours (102,582 miles) throughout 18 months of service, the 2.7L V6 engine from a 2010 Dodge Charger was disassembled and analyzed. The vehicle averaged 14.6 mph throughout 18 months of service, illustrating severity of service.

Transmission

Following 12,891 hours (183,705 miles) the 4-speed automatic transmission (model #42RLE) from a second 2010 Dodge Charger was removed from service for analysis. The vehicle averaged 14.3 mph throughout 27 months in service.

Both vehicles operated throughout the field study with the following lubricants:

Engine: AMSOIL Signature Series 0W-20 Synthetic Motor Oil

Transmission: AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid

¹ Conversion based on average mph in city driving (21.2) and highway driving (48.3) according to the Environmental Protection Agency's (EPA) Federal Test Procedure (FTP) Driving Schedule and Highway Fuel Economy Test (HWFET). See http://www.fueleconomy.gov/feg/fe_test_schedules.shtml.

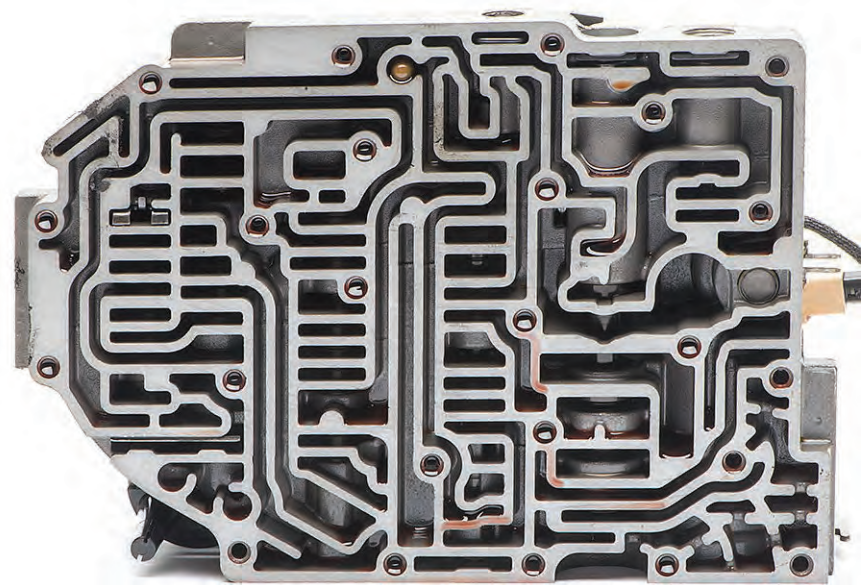
PART ONE

TRANSMISSION RESULTS

Although the taxi company typically changed transmission fluid every 20,000 miles, the drain interval in the test vehicle presented in this study using AMSOIL Signature Series Synthetic ATF was extended to more than 180,000 miles – 3X original equipment manufacturer recommendations – to increase severity.

Component Analysis & Ratings

Valve Body



Rating	
Valve Body Sludge Deposits	9.8

In addition to regulating fluid pressure, the valve body directs fluid for actuating the servos and clutch packs used in shifting. Due to the high number of narrow passages, the valve body is especially sensitive to the negative effects of fluid oxidation and sludge formation. The valve body earned a high rating for sludge deposits, particularly when considering the elevated heat and shifting frequency. Signature Series Multi-Vehicle Synthetic ATF demonstrated excellent resistance to extreme heat and sludge formation.

Transmission Sump Pan & Suction Screen



Note: Transmission pan is manufactured to be black in color.



Rating	
Sump Pan Sludge Deposits	9.25
%, Screen Clogging	< 5%

The transmission sump pan earned a high rating of 9.25. The suction screen demonstrated minimal clogging, earning a rating of less than 5 percent. Results confirm the effectiveness of the transmission fluid in resisting extreme heat, sludge and wear.

Clutch Plates (Gears 2 & 4)



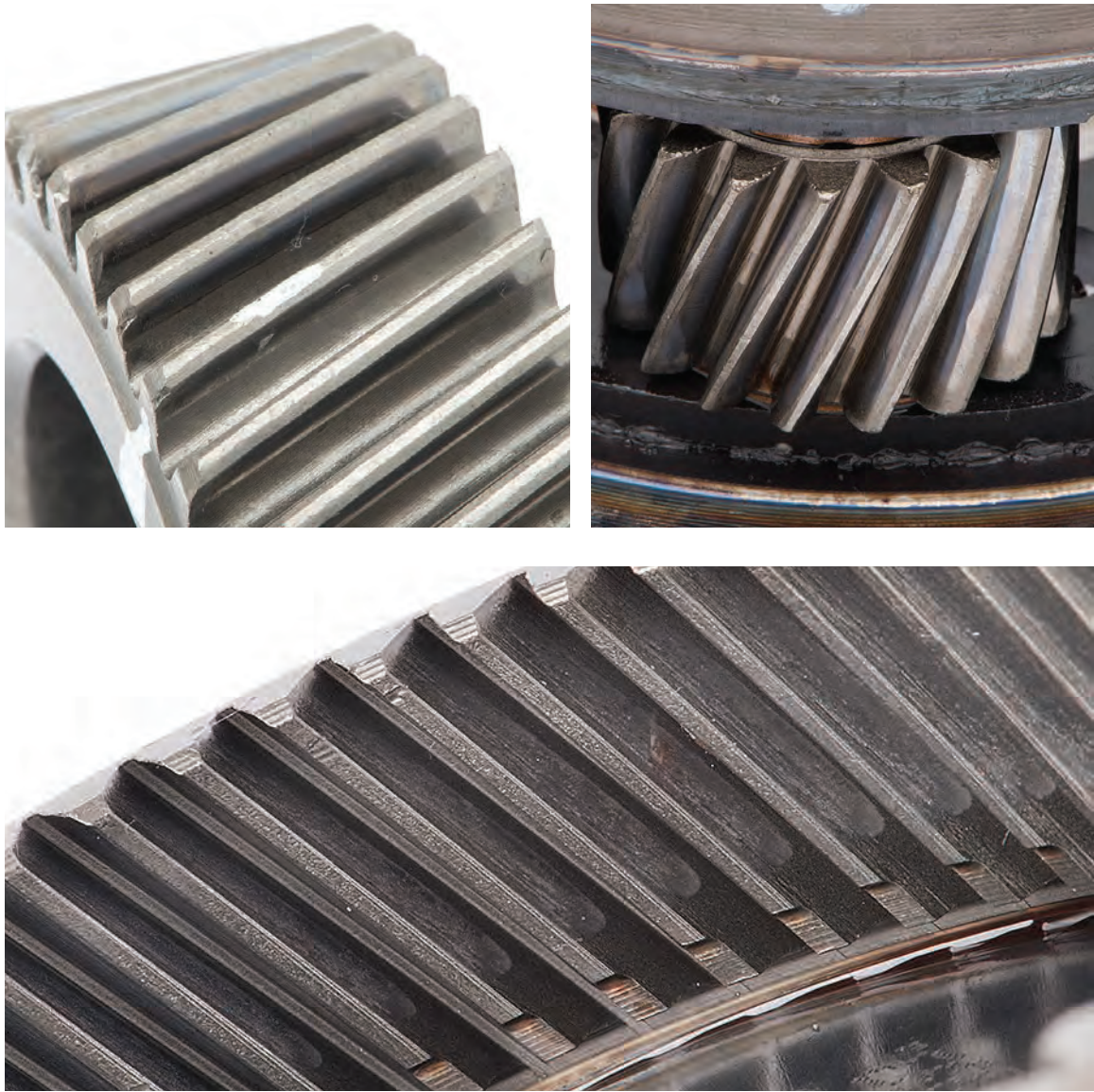
Manufacturer's stamp still visible.

Rating	
Discoloration	Trace
Deterioration/Wear	Good

Clutch packs are used to control movement of the planetary gear sets. The pack consists of alternate clutch plates lined with friction material and bare steel plates. Hydraulic pressure activates the clutch pack, squeezing the plates together to enable gear shifts. The process causes the clutch plates to bear friction repeatedly, inviting wear.

The clutch plates demonstrated only trace discoloration from heat. The manufacturer's stamping is still visible on the friction material despite it being a wear surface. In addition, the clutch plates earned the highest rating possible ("good") for deterioration/wear. Signature Series Multi-Vehicle Synthetic ATF prevented clutch glazing, ensuring excellent shift quality and strong protection for 12,891 hours (183,705 miles).

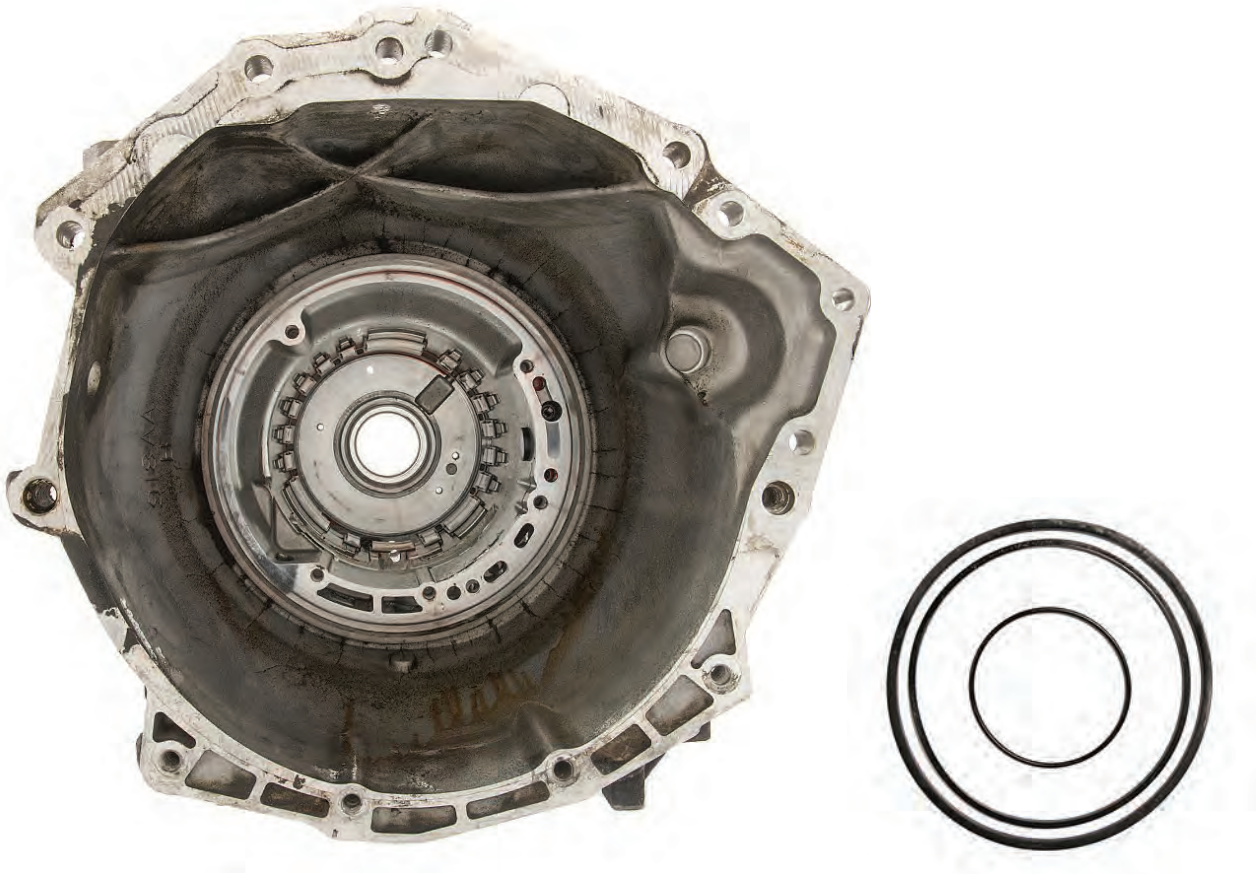
Planet, Sun & Ring Gears



	Rating
Planet Gear	Trace/Light
Sun Gear	Trace/Light
Ring Gear	Trace

The frequent shifts and demanding driving conditions common to taxi applications create the opportunity for excessive transmission gear wear. The planet and sun gears contained only “trace/light” wear, while the ring gear demonstrated only “trace” wear. Results indicate Signature Series Multi-Vehicle Synthetic ATF maintained its protective properties and provided a high level of wear protection in one of the most severe environments possible.

Transmission Case & Seals



	Rating
Transmission Case Sludge Deposits	9.8

Seals	Rating
Condition	Good
Softness	None
Lightness/Firmness	None
Firmness	None
Hardness	None
Brittleness	None
Cracking	None
Discoloration	None

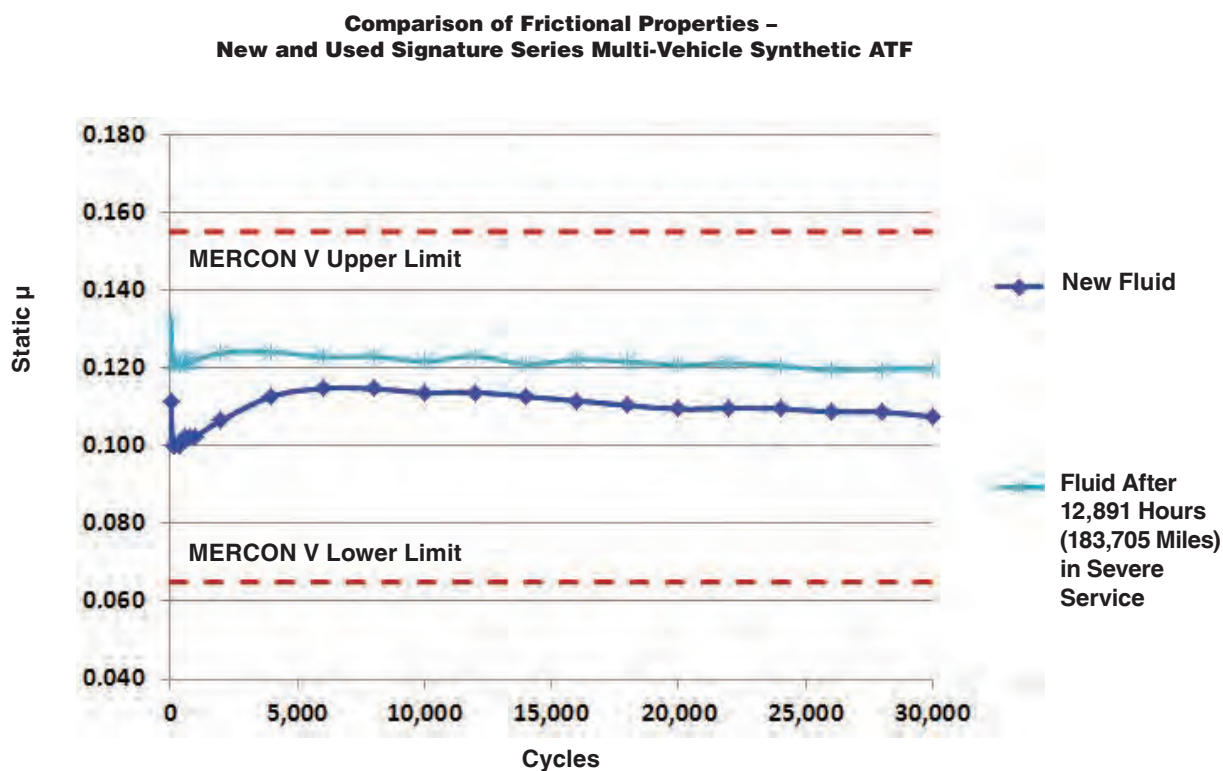
The transmission case was clean and virtually free of sludge. All transmission seals were found to be in “good” condition (the highest rating), with no cracking, discoloration or other stress detected. Results demonstrate Signature Series Multi-Vehicle ATF’s ability to protect seals exposed to high heat and severe-service operating conditions, providing long-term leak protection.

Used Transmission Fluid Analysis

After 12,891 hours (183,705 miles) in use, samples of the transmission fluid were subjected to laboratory bench testing for additional proof of performance.

Friction Durability of Used Fluid

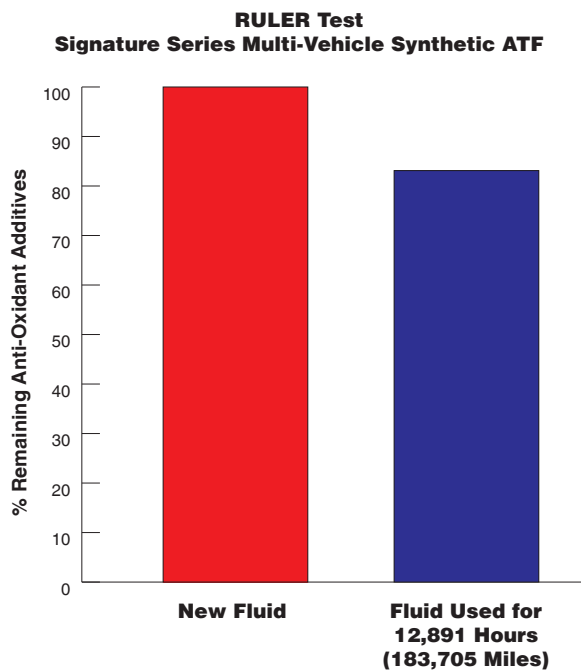
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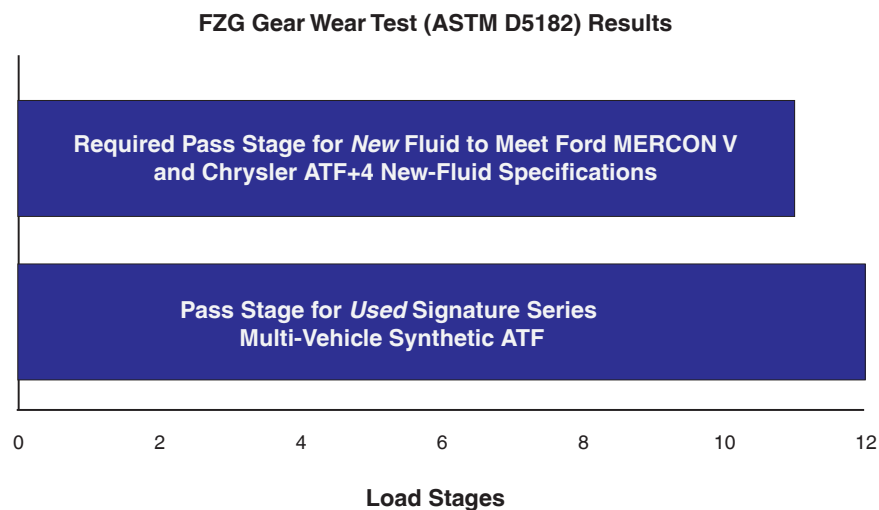
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FZG Gear Wear Test (ASTM D5182)

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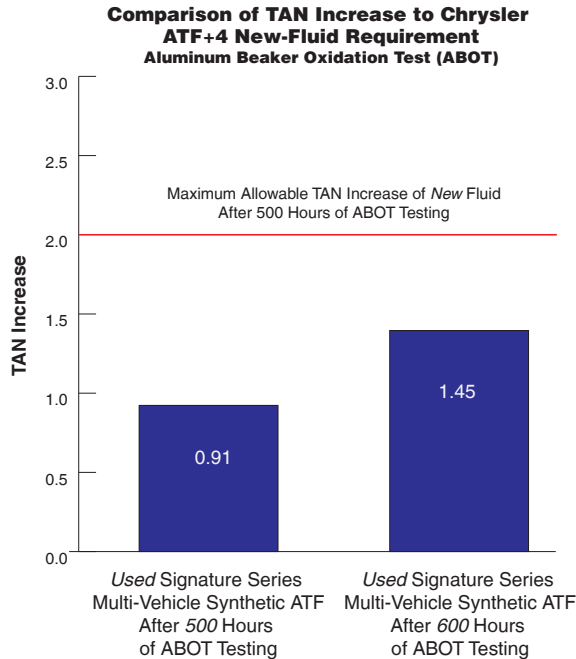


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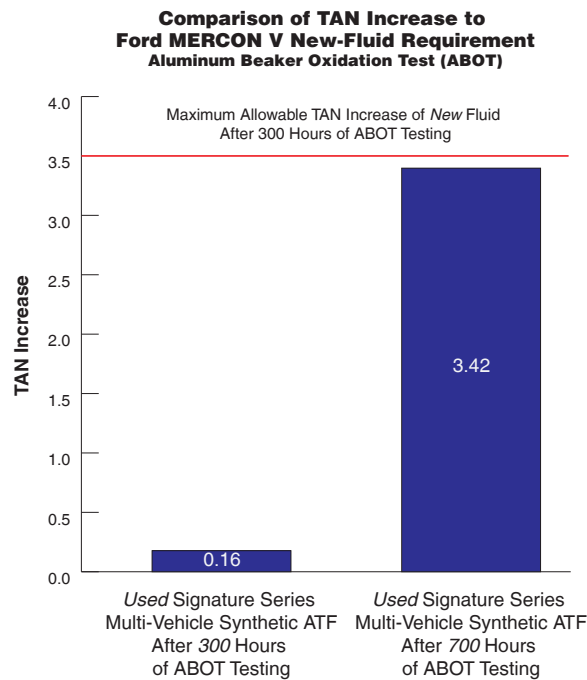
The properties of Signature Series Synthetic ATF that had been used for 12,891 hours (183,705 miles) in severe service were compared to new-fluid specifications for TAN and viscosity increase. Because the amount of fluid available for testing was limited, percent viscosity increase was not determined beyond 300 hours of ABOT testing.



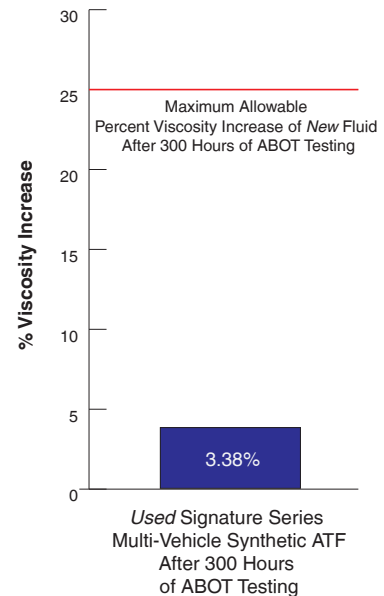
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Even after 12,891 hours (183,705 miles) of use in severe service, the lubricant surpassed the TAN requirements for new fluid to meet the Chrysler ATF+4 and Ford MERCON V requirements. Signature Series Multi-Vehicle Synthetic ATF continued providing a high level of protection throughout the entire drain interval and was suitable for continued use.



Comparison of Viscosity Increase to Ford MERCON V New-Fluid Requirement
Aluminum Beaker Oxidation Test (ABOT)



PART TWO

ENGINE RESULTS

As noted earlier, oil change intervals were determined in hours during the field study. The average oil change interval for the Dodge Charger was 1,005 hours (14,619 miles). The Environmental Protection Agency's (EPA) Federal Test Procedure (FTP) Driving Schedule and Highway Fuel Economy Test (HWFET)¹ were used to convert the Charger's 1,005 hours of operating time between oil changes to total miles likely to be accumulated by an average motorist. Results are shown below.

Dodge Charger Hourly Oil Change Interval Converted to Miles

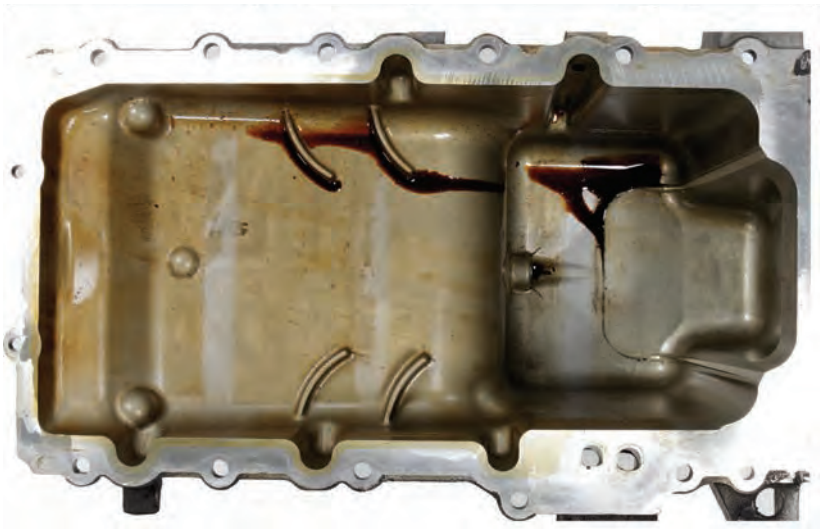
Hours on Oil		City Driving (21.2 mph/avg.) ¹	Highway Driving (48.3 mph/avg.) ¹
1,005	=	21,306 miles	48,542 miles

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Component Analysis & Ratings

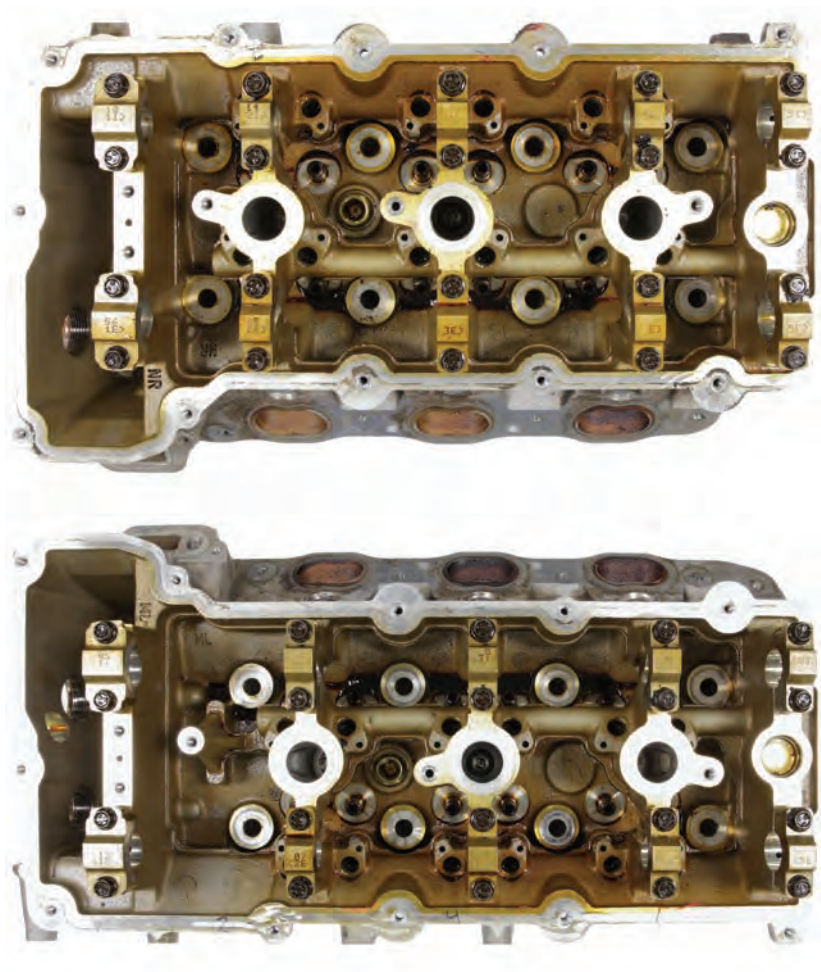
Oil Pan & Pickup Tube



	Rating
Oil Pan Sludge Deposits	9.63
Oil Pan Varnish Deposits	9.00
% Clogging, Oil Screen	1

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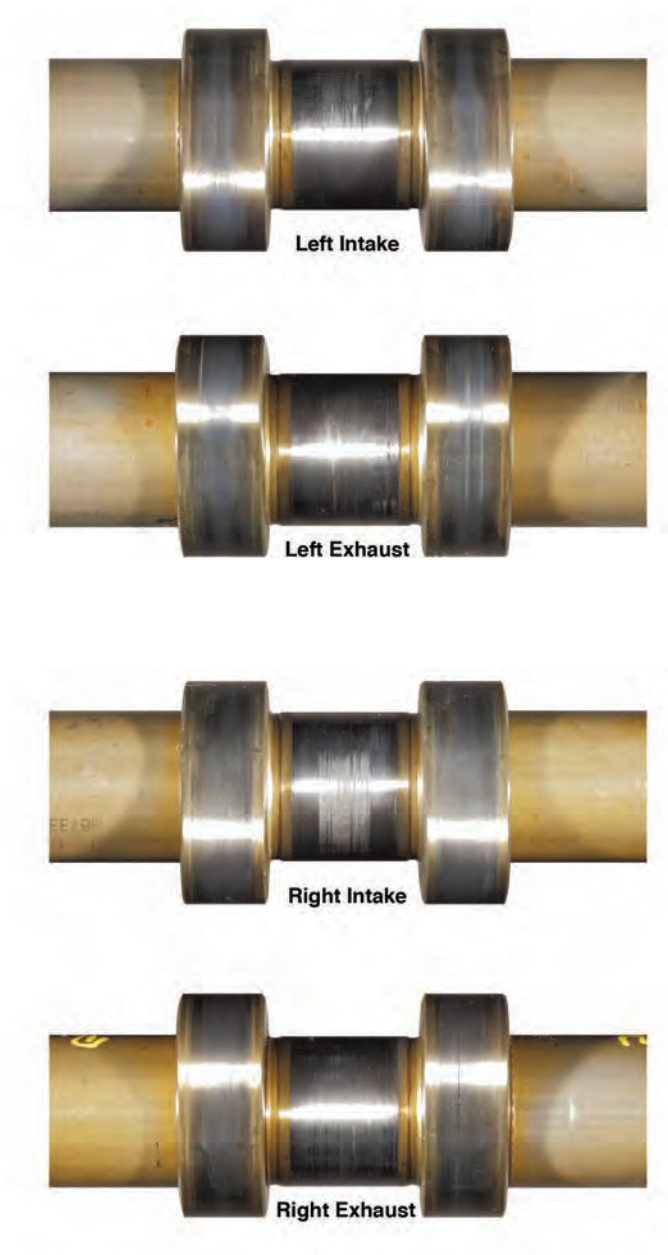
Cylinder Heads



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Like the oil pan, the cylinder heads are prone to accumulating sludge if using motor oils with poor thermal stability. Following 7,033 hours (102,582 miles), the cylinder heads contained no black sludge, earned high ratings and demonstrated superior cleanliness despite the challenging operating conditions. Signature Series Synthetic Motor Oil exhibited outstanding thermal stability.

Camshaft Lobes



Excessive sludge formation can cause oil starvation, particularly in the upper valvetrain due to narrow oil passages and the distance the oil must travel. The cam lobes exhibited very little wear, with no visible flaking or spalling. Signature Series Synthetic Motor Oil demonstrated excellent wear protection in addition to sludge resistance throughout 7,033 hours (102,582 miles).

Front Cover & Seal



Front Cover	Rating
Sludge Deposits	9.84
Varnish Deposits	9.60

Seals	Rating
Hardening	None
Cracking	None
Softening	None
Blistering	None
Varnishing	Very Light
Chunking	None
Carboning	Moderate
Wear	None
Grooving	None
Leakage	None

The front cover, also referred to as the timing chain cover, is clean and virtually free of sludge or varnish. The front cover seal remained in excellent condition throughout the study, with only very light varnish and no wear, leakage or other distress. Signature Series Synthetic Motor Oil demonstrated excellent seal compatibility and protection.

Conclusion

Field testing proves that AMSOIL Signature Series Multi-Vehicle Synthetic ATF and AMSOIL Signature Series Synthetic Motor Oil provide superior protection against sludge and wear for extended drain intervals in severe service. Components from a Las Vegas cab's transmission revealed minimal distress despite accumulating 12,891 hours (183,705 miles) of severe service on a single fluid change. The valve body earned a high rating for sludge deposits while the clutch plates revealed no discoloration and little wear. Used transmission fluid analysis revealed the fluid still met TAN requirements of new fluid for the Chrysler ATF+4 and Ford MERCON V specifications. Used fluid also demonstrated wear protection in the FZG Gear Wear Test identical to new fluid, providing additional proof of performance.

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Editor's Note:

AMSOIL published the first edition of the *Las Vegas Taxi Cab Field Study* in April 2013. Results demonstrated the excellent performance of AMSOIL synthetic lubricants in severe-service commercial applications operating in the searing Las Vegas heat. The original transmission accumulated more than 102,000 miles on a single fluid change. To further test the capabilities of AMSOIL Signature Series Multi-Vehicle Synthetic Transmission Fluid, it was installed in another taxi that was operated for 12,891 hours (183,705 miles) – 3X original equipment manufacturer recommendations – on a single fluid change. Those results are presented here along with the engine results from the first edition of this study.

Overview

Few applications place more stress on lubricants than taxi cabs, particularly those operating in the desert heat of Las Vegas, Nev. The combination of excessive idling, stop-and-go driving and high ambient temperatures creates the ideal scenario for lubricant failure, resulting in sludge formation and catastrophic component failure.

Fleet vehicles, heavy-duty pickups, work trucks and other commercial applications operate under severe service. In addition, drain intervals are getting longer. For engines and transmissions to last as designed and achieve maximum performance, lubricants today must protect against elevated heat and its associated problems for longer periods of service.

Objective

Demonstrate that AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid and Signature Series Synthetic Motor Oil protect against extreme heat and sludge formation during extended drain intervals in vehicles routinely operated in severe conditions. Further demonstrate that the lubricants meet the increased performance demands of modern fleet, commercial and other professional vehicles.

Method

In conducting this field study, AMSOIL sought a test partner with vehicles used in the most demanding conditions possible. A Las Vegas taxi company was selected due to the challenges inherent to taxi applications and the extreme desert heat, which presented a worst-case scenario that further challenged the lubricants. In fact, the taxi company had been experiencing rampant engine failure using synthetic blend motor oil recommended for API SN/ILSAC GF-5 service requirements and changed every 5,000 miles. Engine failures occurred predominantly during hot summer months due to excess sludge clogging the oil pickup tubes and starving the engines of oil. The severity of service also required frequent transmission fluid changes (every 20,000 miles).

Signature Series Synthetic Automatic Transmission Fluid and Signature Series Synthetic Motor Oil were installed in six of the fleet's vehicles. The test vehicles were placed into service and operated within the fleet's service area of Las Vegas up to 24 consecutive hours each day, with the engines often shut down only during refueling or personnel changes. Excessive time idling combined with stop-and-go driving loaded with passengers and cargo characterized typical driving conditions. During summer months, ambient temperatures often exceeded 100°F, further increasing severity.

Motor oil in the test vehicles was scheduled to be changed at a minimum of 900-hour intervals. The actual motor oil change intervals for the engine reported in this study were 1,005 hours (approximately 15,000 miles). Transmission fluid was not changed in any of the vehicles.

Note: Oil change intervals were determined using hours rather than miles due to excessive idling and low-speed driving. In these conditions, hours of service provides a more accurate measure of the oil's service life. To illustrate the severity of service for the average motorist, 900 hours of total operating time is equivalent to 19,080 miles in city driving conditions and 43,470 miles in on-highway conditions.¹

Following testing, engine and transmission parts were rated for sludge, wear and other distress by an independent calibrated rater according to the criteria given in the appropriate Coordinating Research Council (CRC) manual. Parts were assigned a numeric rating on a descending scale, with 10 representing no distress and 0 representing catastrophic distress. Some parts were assigned a descriptive rating (e.g. "None", "Good", etc.) describing the level of distress. Results are divided into two parts, one for the transmission and the other for the engine.

Vehicles Selected for Teardown & Analysis

Engine

After accumulating 7,033 hours (102,582 miles) throughout 18 months of service, the 2.7L V6 engine from a 2010 Dodge Charger was disassembled and analyzed. The vehicle averaged 14.6 mph throughout 18 months of service, illustrating severity of service.

Transmission

Following 12,891 hours (183,705 miles) the 4-speed automatic transmission (model #42RLE) from a second 2010 Dodge Charger was removed from service for analysis. The vehicle averaged 14.3 mph throughout 27 months in service.

Both vehicles operated throughout the field study with the following lubricants:

Engine: AMSOIL Signature Series 0W-20 Synthetic Motor Oil

Transmission: AMSOIL Signature Series Multi-Vehicle Synthetic Automatic Transmission Fluid

¹ Conversion based on average mph in city driving (21.2) and highway driving (48.3) according to the Environmental Protection Agency's (EPA) Federal Test Procedure (FTP) Driving Schedule and Highway Fuel Economy Test (HWFET). See http://www.fueleconomy.gov/feg/fe_test_schedules.shtml.

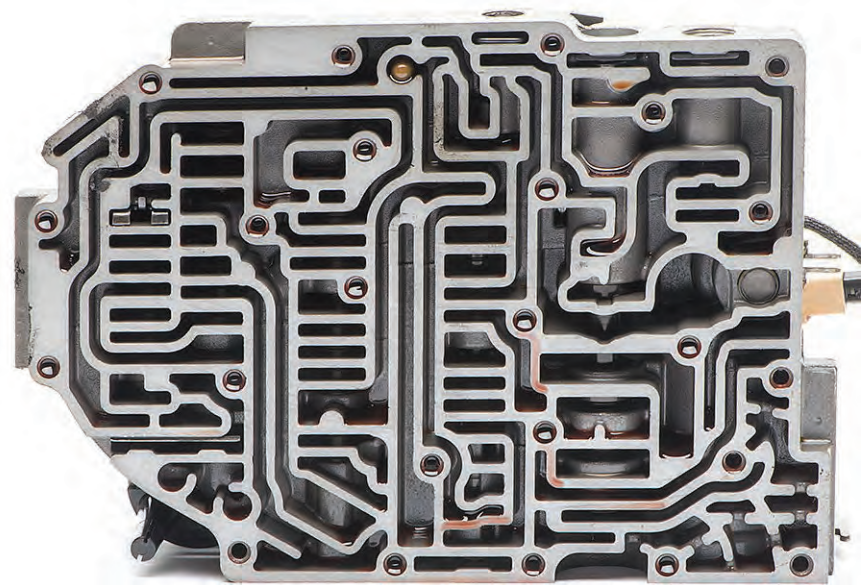
PART ONE

TRANSMISSION RESULTS

Although the taxi company typically changed transmission fluid every 20,000 miles, the drain interval in the test vehicle presented in this study using AMSOIL Signature Series Synthetic ATF was extended to more than 180,000 miles – 3X original equipment manufacturer recommendations – to increase severity.

Component Analysis & Ratings

Valve Body



Rating	
Valve Body Sludge Deposits	9.8

In addition to regulating fluid pressure, the valve body directs fluid for actuating the servos and clutch packs used in shifting. Due to the high number of narrow passages, the valve body is especially sensitive to the negative effects of fluid oxidation and sludge formation. The valve body earned a high rating for sludge deposits, particularly when considering the elevated heat and shifting frequency. Signature Series Multi-Vehicle Synthetic ATF demonstrated excellent resistance to extreme heat and sludge formation.

Transmission Sump Pan & Suction Screen



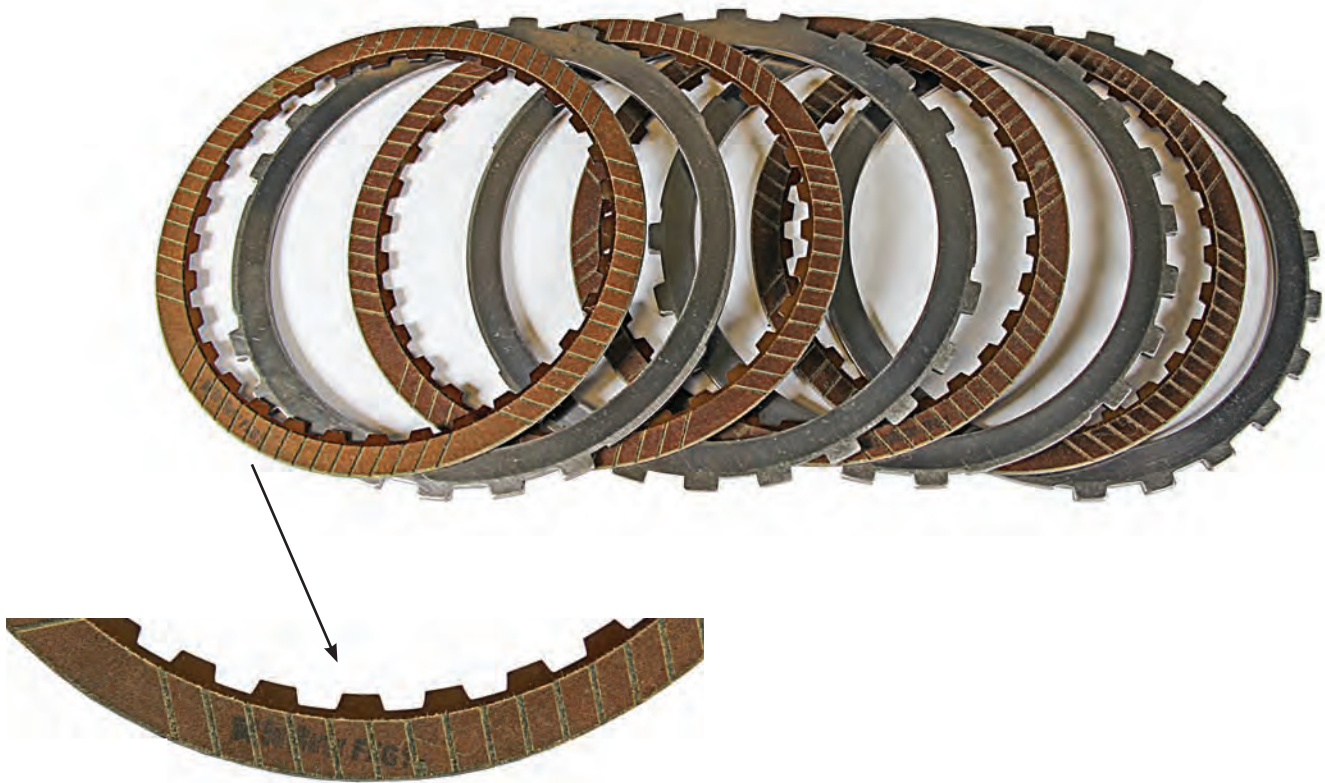
Note: Transmission pan is manufactured to be black in color.



Rating	
Sump Pan Sludge Deposits	9.25
%, Screen Clogging	< 5%

The transmission sump pan earned a high rating of 9.25. The suction screen demonstrated minimal clogging, earning a rating of less than 5 percent. Results confirm the effectiveness of the transmission fluid in resisting extreme heat, sludge and wear.

Clutch Plates (Gears 2 & 4)



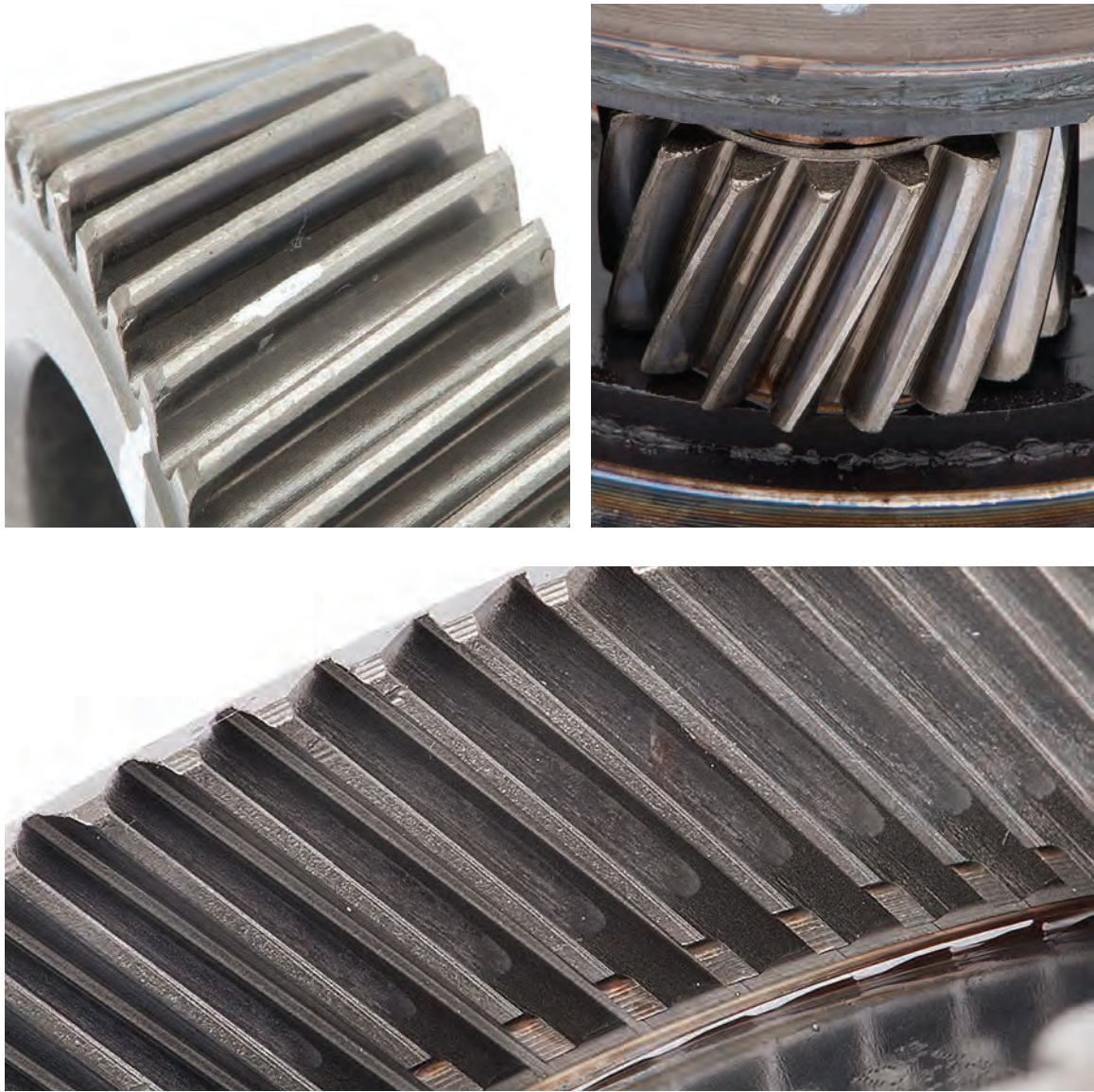
Manufacturer's stamp still visible.

Rating	
Discoloration	Trace
Deterioration/Wear	Good

Clutch packs are used to control movement of the planetary gear sets. The pack consists of alternate clutch plates lined with friction material and bare steel plates. Hydraulic pressure activates the clutch pack, squeezing the plates together to enable gear shifts. The process causes the clutch plates to bear friction repeatedly, inviting wear.

The clutch plates demonstrated only trace discoloration from heat. The manufacturer's stamping is still visible on the friction material despite it being a wear surface. In addition, the clutch plates earned the highest rating possible ("good") for deterioration/wear. Signature Series Multi-Vehicle Synthetic ATF prevented clutch glazing, ensuring excellent shift quality and strong protection for 12,891 hours (183,705 miles).

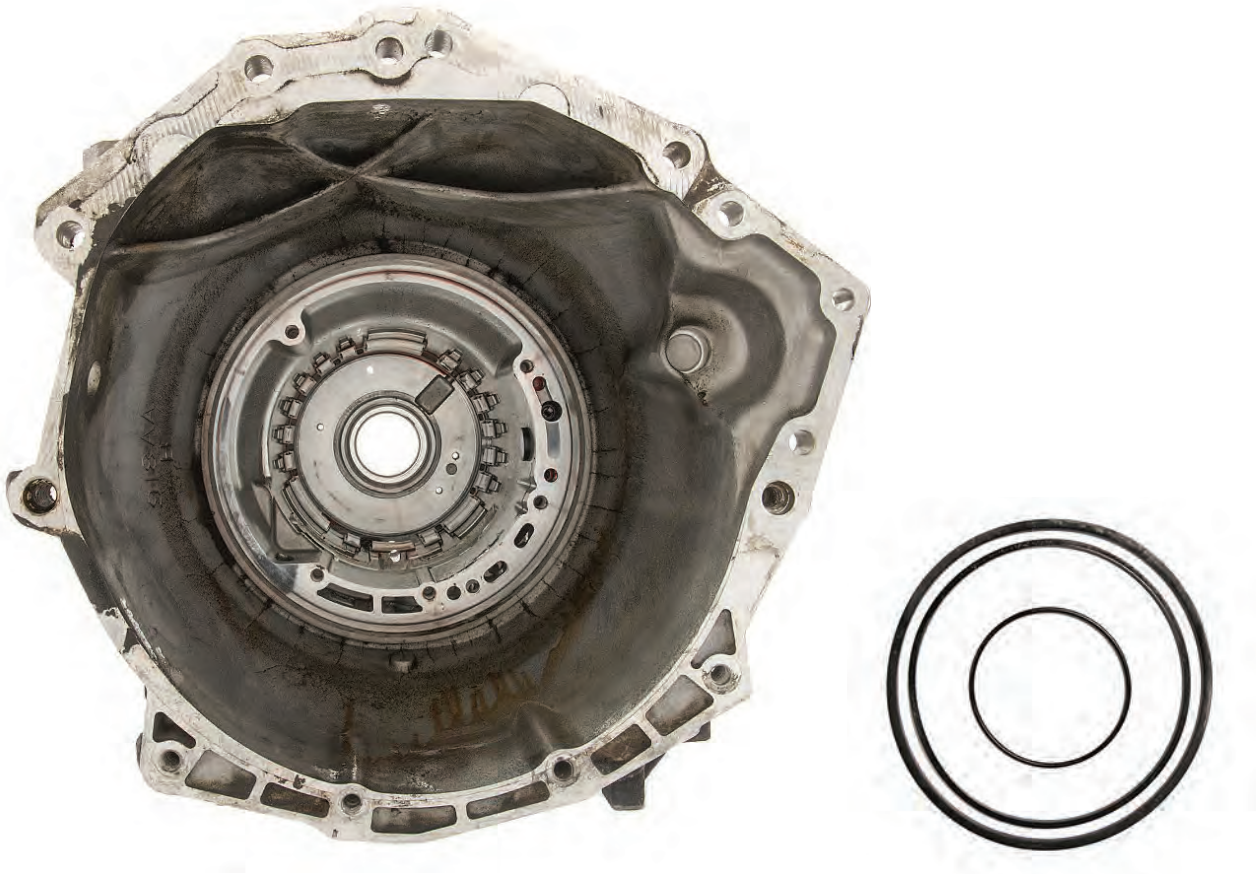
Planet, Sun & Ring Gears



	Rating
Planet Gear	Trace/Light
Sun Gear	Trace/Light
Ring Gear	Trace

The frequent shifts and demanding driving conditions common to taxi applications create the opportunity for excessive transmission gear wear. The planet and sun gears contained only “trace/light” wear, while the ring gear demonstrated only “trace” wear. Results indicate Signature Series Multi-Vehicle Synthetic ATF maintained its protective properties and provided a high level of wear protection in one of the most severe environments possible.

Transmission Case & Seals



	Rating
Transmission Case Sludge Deposits	9.8

Seals	Rating
Condition	Good
Softness	None
Lightness/Firmness	None
Firmness	None
Hardness	None
Brittleness	None
Cracking	None
Discoloration	None

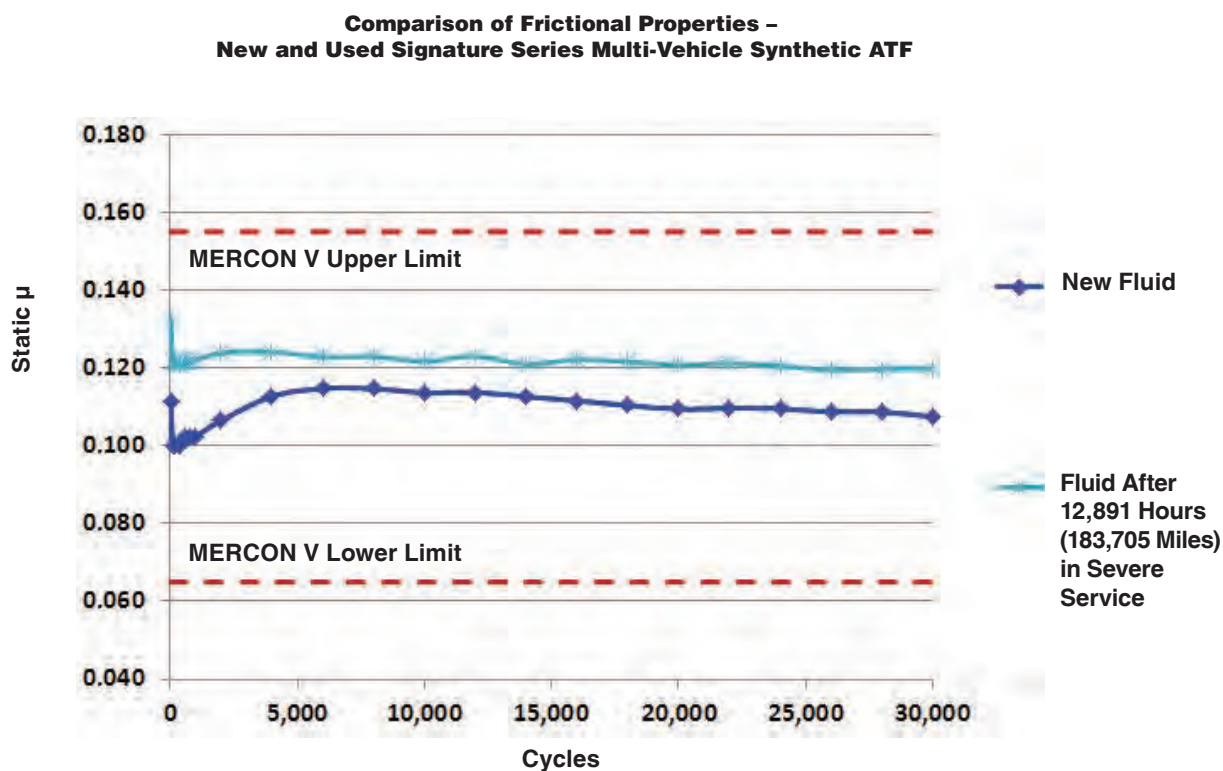
The transmission case was clean and virtually free of sludge. All transmission seals were found to be in “good” condition (the highest rating), with no cracking, discoloration or other stress detected. Results demonstrate Signature Series Multi-Vehicle ATF’s ability to protect seals exposed to high heat and severe-service operating conditions, providing long-term leak protection.

Used Transmission Fluid Analysis

After 12,891 hours (183,705 miles) in use, samples of the transmission fluid were subjected to laboratory bench testing for additional proof of performance.

Friction Durability of Used Fluid

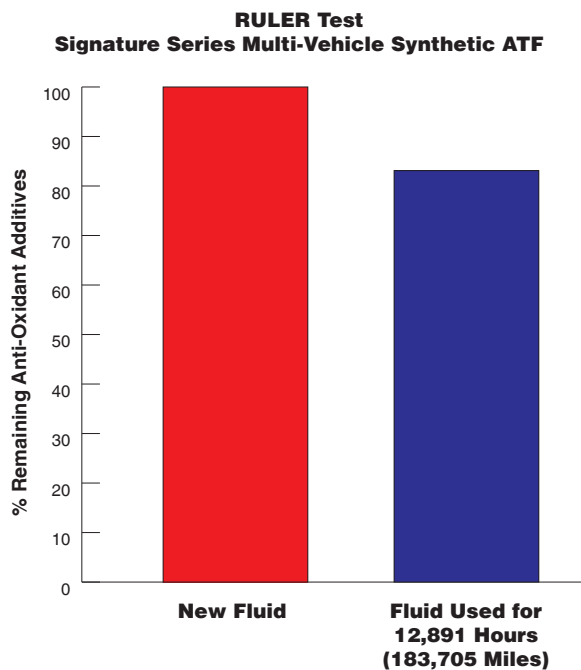
The transmission fluid's frictional properties are critical to proper operation of clutch packs. Over time, fluids exposed to extreme heat can fail to provide the correct frictional properties, resulting in clutch glazing, slipping, shudder, hard shifts and excessive wear. To determine the friction durability of Signature Series Multi-Vehicle Synthetic ATF in severe service, used fluid was analyzed with the SAE #2 Friction Test Machine using Borg Warner SD1777 friction plates specified in the Ford MERCON® V transmission fluid specification. (Chrysler maintains the friction material used in its ATF+4® transmission fluid specification as proprietary, thus it could not be obtained for the test.) The test subjected clutch packs to 30,000 cycles, during which the clutch engagement stops a spinning mass. Torque and time are measured, which provides the data required to determine the fluid's frictional properties. Results were compared to new fluid to determine any reduction. Ford MERCON V upper and lower limits are included as benchmarks.



Signature Series Multi-Vehicle Synthetic ATF used for 12,891 hours (183,705 miles) in severe service demonstrated frictional properties similar to new fluid. Results indicate the fluid excelled in maintaining its frictional properties and provided superior shift quality throughout the entire field study despite the severe operating conditions.

Remaining Useful Life Evaluation Routine (RULER) Test

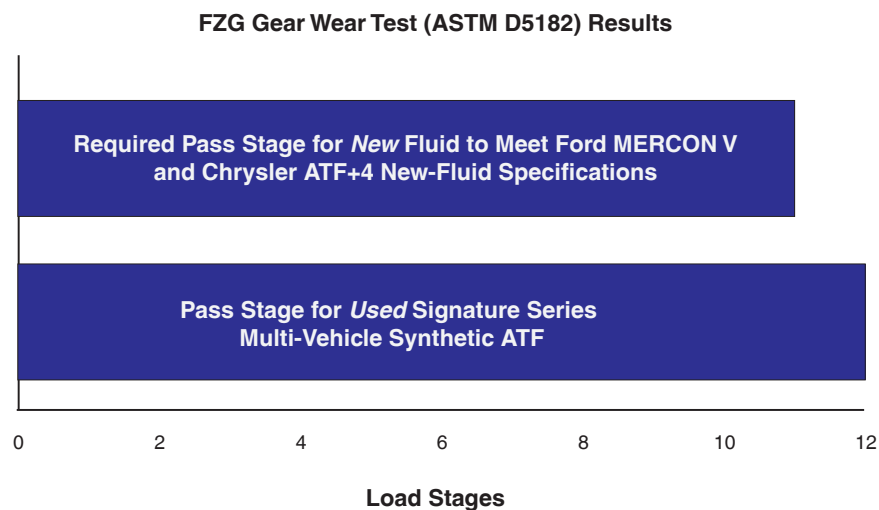
The Remaining Useful Life Evaluation Routine (RULER) Test measures the concentration of anti-oxidant additives remaining in the lubricant. As oil degrades over time, additives deplete, resulting in a corresponding decrease in the RULER value. The RULER Test compares the antioxidant concentration of used oil to the antioxidant concentration of new oil.



After 12,891 hours (183,705 miles), Signature Series Multi-Vehicle Synthetic ATF contained 83 percent of its original oxidation inhibitors. Results confirm the fluid's ability to provide reserve protection in transmissions that experience severe operating conditions.

FZG Gear Wear Test (ASTM D5182)

The FZG Gear Wear Test is designed to assess a lubricating fluid's ability to resist gear tooth scuffing. To simulate operating conditions, a machine operates at 1,450 rpm through up to 12 progressive stages that increase in load every 15 minutes. In accordance with the Chrysler ATF+4 and Ford MERCON V specifications, the test was conducted at 150°C. After each load stage, the gear teeth were inspected for scuffing and weighed to record any weight loss. Both new-lubricant specifications require a stage 11 pass.

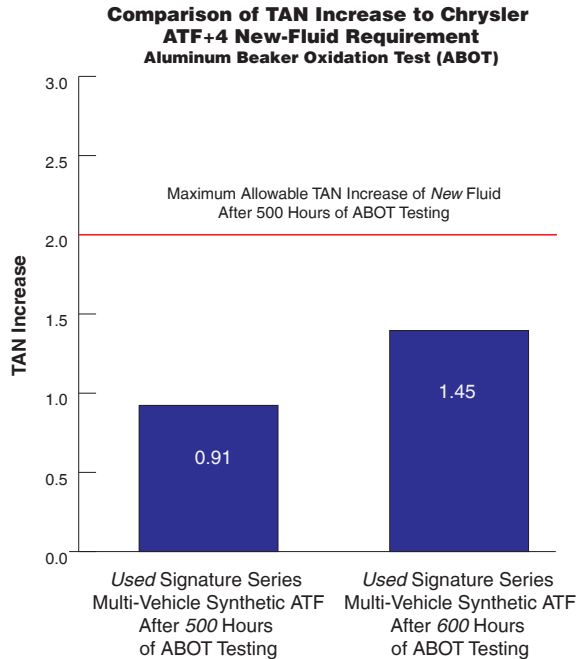


Signature Series Multi-Vehicle Synthetic ATF used for 12,891 hours (183,705 miles) passed all 12 load stages, with no noticeable difference in wear protection between new and used fluid. Results confirm the superior wear protection provided by the lubricant in severe operating conditions.

Comparison of Used Fluid to New-Fluid Specifications

Many original equipment manufacturers (OEMs) publish specifications that new, unused transmission fluids must meet to be used in the OEMs' equipment. For example, to meet the Chrysler ATF+4 specification, transmission fluid subjected to the Aluminum Beaker Oxidation Test (ABOT) for 500 hours must demonstrate a total acid number (TAN) increase of two or less. To meet the Ford MERCON V new-fluid specification (included for additional comparison), the fluid's TAN increase after 300 hours of ABOT testing must remain below 3.5. Excessive increases in TAN can be an indicator the fluid has reached its condemnation limit.

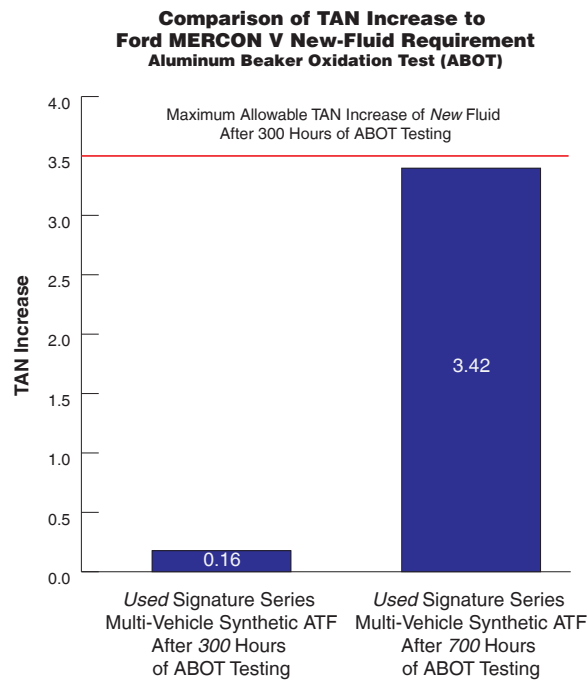
The properties of Signature Series Synthetic ATF that had been used for 12,891 hours (183,705 miles) in severe service were compared to new-fluid specifications for TAN and viscosity increase. Because the amount of fluid available for testing was limited, percent viscosity increase was not determined beyond 300 hours of ABOT testing.



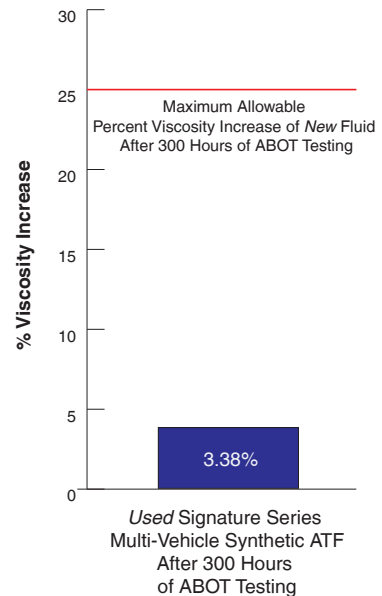
Following 500 hours of ABOT testing, the TAN of used Signature Series Multi-Vehicle Synthetic ATF increased by .91, remaining below the maximum allowable to meet the Chrysler ATF+4 new-fluid specification. Even after continuing testing to 600 hours, the lubricant's TAN increase met the requirement for new fluid.

Comparing to the Ford MERCON V specification produced similar results. The lubricant's TAN increase after 300 hours of ABOT testing (0.16) remained below the maximum allowable. After more than doubling the required hours of testing to 700 hours, the lubricant's TAN increase (3.42) still remained below the threshold. The lubricant's viscosity increase after 300 hours (3.38 percent) was also below the maximum allowable percent increase to meet the Ford MERCON V new-fluid specification.

Even after 12,891 hours (183,705 miles) of use in severe service, the lubricant surpassed the TAN requirements for new fluid to meet the Chrysler ATF+4 and Ford MERCON V requirements. Signature Series Multi-Vehicle Synthetic ATF continued providing a high level of protection throughout the entire drain interval and was suitable for continued use.



Comparison of Viscosity Increase to Ford MERCON V New-Fluid Requirement
Aluminum Beaker Oxidation Test (ABOT)



PART TWO

ENGINE RESULTS

As noted earlier, oil change intervals were determined in hours during the field study. The average oil change interval for the Dodge Charger was 1,005 hours (14,619 miles). The Environmental Protection Agency's (EPA) Federal Test Procedure (FTP) Driving Schedule and Highway Fuel Economy Test (HWFET)¹ were used to convert the Charger's 1,005 hours of operating time between oil changes to total miles likely to be accumulated by an average motorist. Results are shown below.

Dodge Charger Hourly Oil Change Interval Converted to Miles

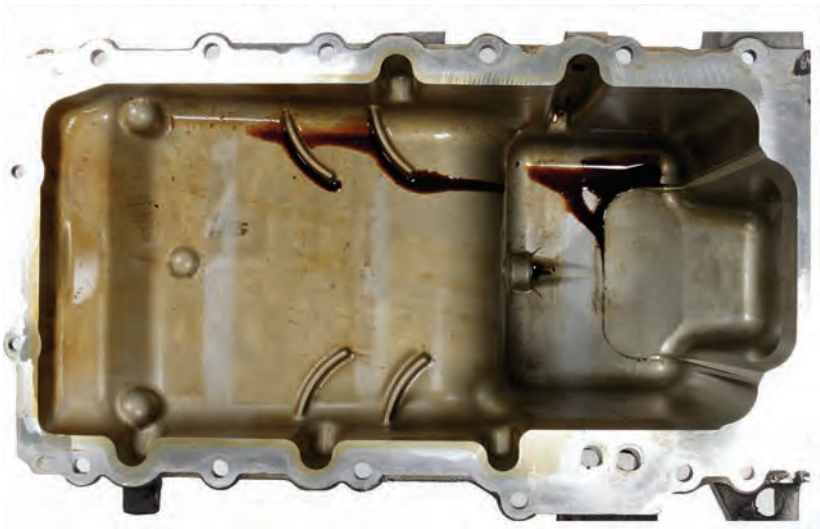
Hours on Oil		City Driving (21.2 mph/avg.) ¹	Highway Driving (48.3 mph/avg.) ¹
1,005	=	21,306 miles	48,542 miles

The Dodge Charger averaged 14.6 mph throughout the field study, increasing severity compared to the EPA city-driving definition. Although the vehicle carries a recommended oil change interval of 6,000 miles/6 months, whichever comes first, its oil change interval was more than doubled.

¹ http://www.fueleconomy.gov/feg/fe_test_schedules.shtml

Component Analysis & Ratings

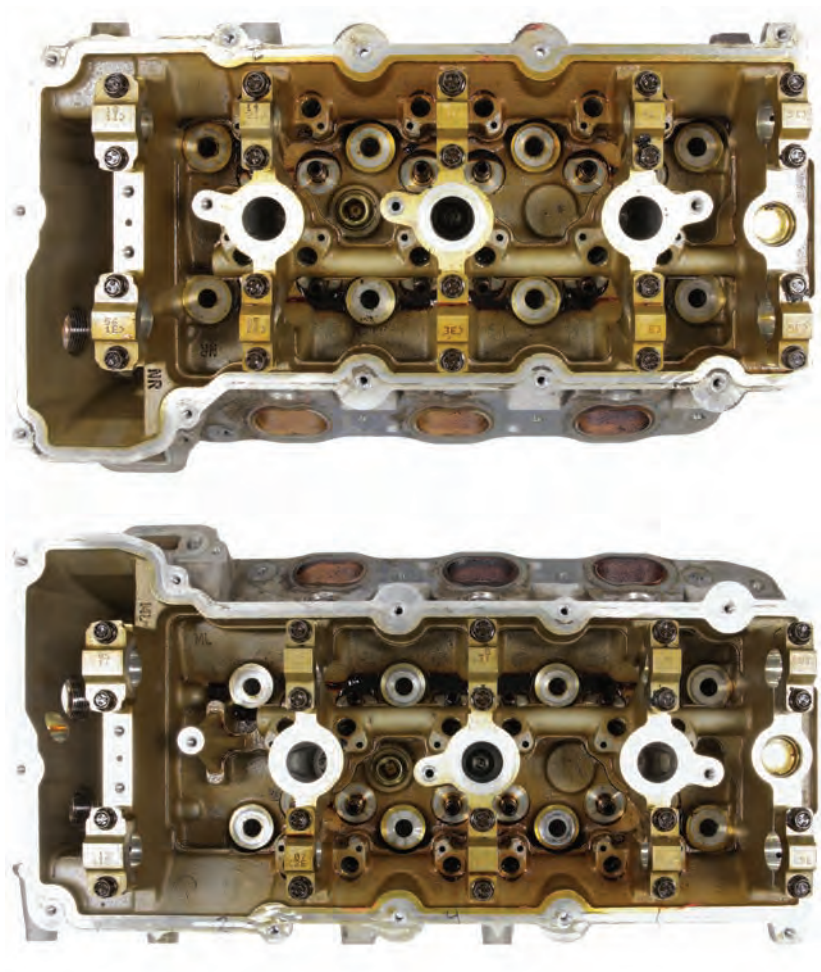
Oil Pan & Pickup Tube



	Rating
Oil Pan Sludge Deposits	9.63
Oil Pan Varnish Deposits	9.00
% Clogging, Oil Screen	1

Motor oils incapable of withstanding extreme heat can allow excessive sludge to accumulate in the oil pan. Sludge can then clog the oil screen on the oil pickup tube, starving the engine of oil and leading to catastrophic failure. Signature Series Synthetic Motor Oil demonstrated superior ability to guard against the formation of sludge, with the oil pan earning a high rating. The oil screen demonstrated 1 percent clogging, proving the oil's ability to provide increased protection in severe service.

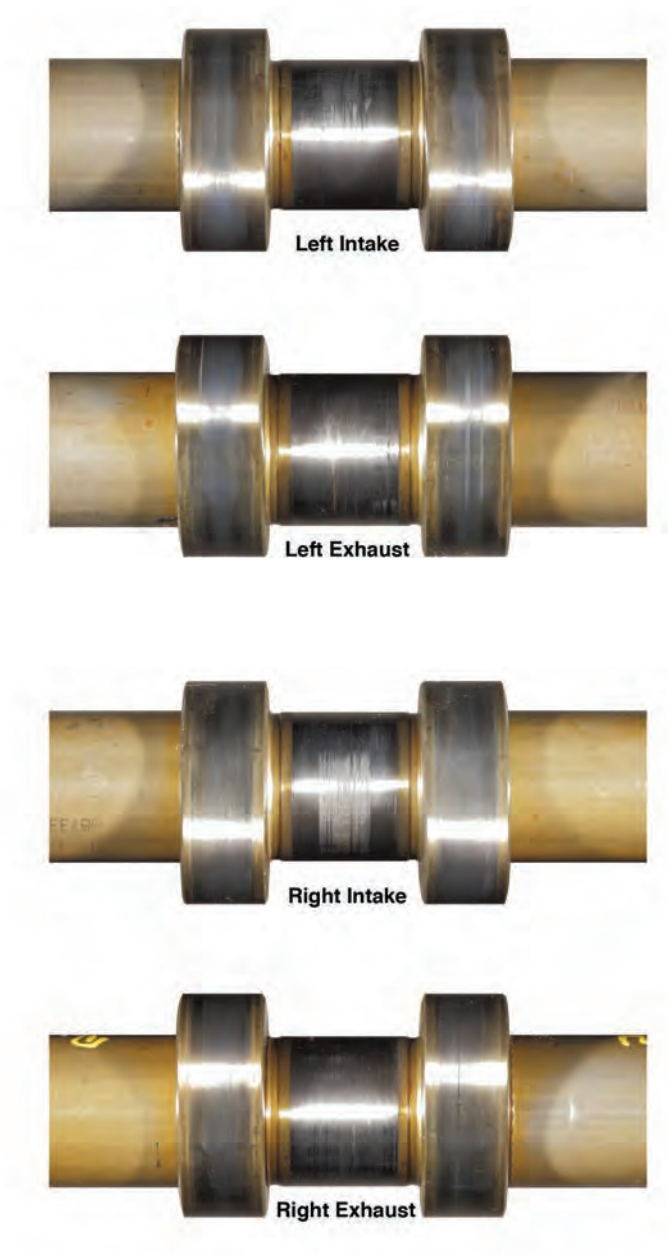
Cylinder Heads



	Rating
Right Valve Deck Sludge Deposits	9.63
Left Valve Deck Sludge Deposits	9.63

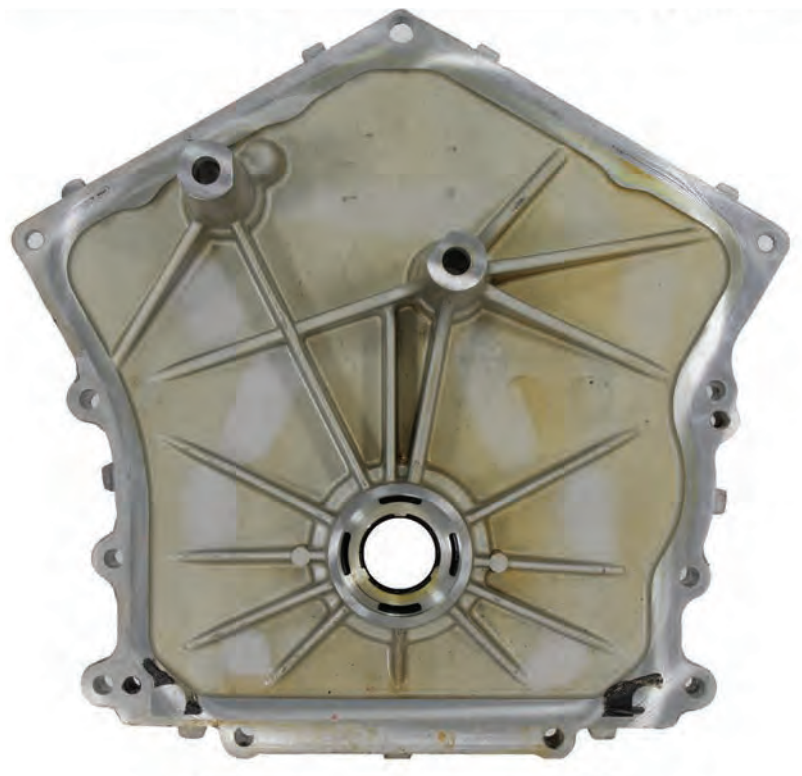
Like the oil pan, the cylinder heads are prone to accumulating sludge if using motor oils with poor thermal stability. Following 7,033 hours (102,582 miles), the cylinder heads contained no black sludge, earned high ratings and demonstrated superior cleanliness despite the challenging operating conditions. Signature Series Synthetic Motor Oil exhibited outstanding thermal stability.

Camshaft Lobes



Excessive sludge formation can cause oil starvation, particularly in the upper valvetrain due to narrow oil passages and the distance the oil must travel. The cam lobes exhibited very little wear, with no visible flaking or spalling. Signature Series Synthetic Motor Oil demonstrated excellent wear protection in addition to sludge resistance throughout 7,033 hours (102,582 miles).

Front Cover & Seal



Front Cover	Rating
Sludge Deposits	9.84
Varnish Deposits	9.60

Seals	Rating
Hardening	None
Cracking	None
Softening	None
Blistering	None
Varnishing	Very Light
Chunking	None
Carboning	Moderate
Wear	None
Grooving	None
Leakage	None

The front cover, also referred to as the timing chain cover, is clean and virtually free of sludge or varnish. The front cover seal remained in excellent condition throughout the study, with only very light varnish and no wear, leakage or other distress. Signature Series Synthetic Motor Oil demonstrated excellent seal compatibility and protection.

Conclusion

Field testing proves that AMSOIL Signature Series Multi-Vehicle Synthetic ATF and AMSOIL Signature Series Synthetic Motor Oil provide superior protection against sludge and wear for extended drain intervals in severe service. Components from a Las Vegas cab's transmission revealed minimal distress despite accumulating 12,891 hours (183,705 miles) of severe service on a single fluid change. The valve body earned a high rating for sludge deposits while the clutch plates revealed no discoloration and little wear. Used transmission fluid analysis revealed the fluid still met TAN requirements of new fluid for the Chrysler ATF+4 and Ford MERCON V specifications. Used fluid also demonstrated wear protection in the FZG Gear Wear Test identical to new fluid, providing additional proof of performance.

Engine parts having accumulated 7,033 hours of service (102,582 miles) demonstrated similar results, with the cylinder heads, oil pan and front cover clean and virtually free of sludge. The motor oil provided superior protection for seals and cam lobes, demonstrating its ability to safely extend drain intervals in severe service.

The performance of each fluid in notoriously severe applications operating in challenging conditions indicates their capability to protect in the harshest environments faced by fleet vehicles, heavy-duty pickups, work trucks and personal passenger cars. Results confirm the fluids' ability to provide reserve protection beyond the severe-service recommendations of original equipment manufacturers (OEMs).



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