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DEVELOPMENT OF AN ARMY STATIONARY AXLE EFFICIENCY TEST STAND

INTERIM REPORT
TFLRF No. 471

by

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U.S. Army TARDEC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

for

Allen S. Comfort
U.S. Army TARDEC
Force Projection Technologies
Warren, Michigan

Contract No. W56HZV-09-C-0100 (WD25)

September 2015

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14. ABSTRACT
The U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC) desires to increase the fuel efficiency of its ground vehicle fleet. A stationary axle test stand has been designed and built in an effort to create a method of determining axle efficiency as a function of the lubricating fluid used. It has been designed based on operating conditions required to replicate a pre-defined transient driving cycle for the tactical wheeled vehicles representing light, medium, and heavy duty equipment. Preliminary repeatability data has been established, and technical investigations and improvements to the test stand have been developed for follow on work. An industry survey of fuel efficient gear oils was also conducted to support overall Army fuel efficient gear oil research.

15. SUBJECT TERMS
Axle lubricant efficiency; FMTV, SCPL, Gear Oil, Engine Oil, HMMWV, Stationary Axle Test, SAE J2360

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EXECUTIVE SUMMARY

The U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC) desires to increase the fuel efficiency of its ground vehicle fleet. One potential area for fuel consumption improvement is through changes in the driveline lubricating fluids. By improving the lubricating fluids to reduce mechanical losses, an increase in vehicle efficiency can be achieved. This report covers the continued progression of TARDEC investigation into driveline efficiency, and documents the design and assembly of a laboratory based stationary axle efficiency test. The primary objectives of the stationary axle stand are:

- Aid in the development of fuel efficient gear oils (FEGO) for U.S. Army equipment.
- Improve understanding of driveline efficiency as it relates to hardware size, operating cycle, and lubricant properties.
- Provide a means for future quantification of efficiency changes in driveline components.

A stationary axle test stand has been designed to accommodate axle hardware representative of light, medium, and heavy tactical wheeled vehicles. The test stand was constructed and installed at the TARDEC Fuels and Lubricants Research Facility located at Southwest Research Institute.

Preliminary baseline testing using SAE J2360 80W90 gear oil has been initiated to establish test stand repeatability. Results show consistent speed and torque input control for testing, and an approximate 0.20 to 0.30% repeatability between back to back evaluations. Further technical improvements to the test stand have been developed, and will be explored under follow on work.

An industry survey was conducted to identify commercially available fuel efficient gear oils. Eight different gear oils were identified as advertising fuel efficiency improvement benefits. Technical data sheets for these products are included in the appendices. Overall, the commercially available fuel efficient gear oils claim to provide a 1 to 1.5% improvement in fuel efficiency. Some selected products are expected to be evaluated after the development of the stationary axle test stand test method is complete.

FOREWORD/ACKNOWLEDGMENTS

The U.S. Army TARDEC Fuel and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, performed this work during the period July 2013 through September 2015 under Contract No. W56HZV-09-C-0100. The U.S. Army Tank Automotive RD&E Center, Force Projection Technologies, Warren, Michigan administered the project. Mr. Eric Sattler (RDTA-SIE-ES-FPT-FLT) served as the TARDEC contracting officer's technical representative. Mr. Allen S. Comfort of TARDEC served as project technical monitor.

The authors would like to acknowledge the contribution of the TFLRF technical and administrative support staff.

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ACRONYMS AND ABBREVIATIONS

AC – alternating current
CAN – controller area network
FEGO – Fuel Efficient Gear Oil
FMTV – Family of Medium Tactical Vehicles
FTM – Federal Test Method
GEP – General Engine Products
GVWR – Gross Vehicle Weight Rating
HMMWV – High Mobility Multipurpose Wheeled Vehicle
hp – horse power
Hz – hertz
KPH – kilometers per hour
ft-lb – pound foot (torque)
MPH – miles per hour
PLS – Palletized Load System
rpm – revolutions per minute
SwRI – Southwest Research Institute
TARDEC – Tank Automotive Research Development and Engineering Center
TFLRF – TARDEC Fuels and Lubricants Research Facility
U.S. – United States
VFD – variable frequency drive
YYMMDD – date format (year, month, day)

1.0 BACKGROUND AND OBJECTIVE

The U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC) desires to increase the fuel efficiency of its ground vehicle fleet. One potential area for fuel consumption improvement is through changes in the driveline lubricating fluids. By improving the lubricating fluids to reduce mechanical losses, an increase in vehicle efficiency can be achieved. These mechanical losses can include frictional, pumping, and churning losses, and depend on the fluids' chemical and physical properties, as well as the vehicle's driveline configuration itself. A relatively small increase in vehicle efficiency through driveline fluid optimization has the potential to provide a significant financial impact when factored over a large fleet such as that operated by the U.S. Army.

TARDEC has previously conducted research to determine fuel consumption effects of engine, transmission, and axle gear lubricants used in light and medium tactical wheeled vehicles. These evaluations have ranged from stationary laboratory dynamometer testing, to full scale vehicle fuel efficiency tests [1,2,3,4]. Results to date show positive improvement gains being possible with only "drop-in" driveline fluid specification changes.

This report covers the continued progression of TARDEC investigation into driveline efficiency, and it documents the design and assembly of a laboratory based stationary axle efficiency test stand. The goals of the axle efficiency test stand were to:

- Aid in the development of fuel efficient gear oils (FEGO) for Army use.
- Improve understanding of driveline efficiency as it relates to hardware size, operating cycle, and lubricant properties.
- Provide a means for future quantification of efficiency changes in driveline components through the establishment of a standardized Federal Test Method (FTM).

In addition to the stationary axle efficiency stand development, an industry survey was conducted to identify current commercially available fuel efficient gear oils to help identify potential lubricant suppliers and technologies to leverage during the fuel efficient gear oil

(FEGO) development process. All work was conducted under contract by the government owned, contractor operated (GOCO) TARDEC Fuels and Lubricants Research Facility (TFLRF), located at Southwest Research Institute (SwRI) in San Antonio, TX.

2.0 STATIONARY AXLE TEST STAND

2.1 STATIONARY AXLE EFFICIENCY STAND DESIGN REQUIREMENTS

The primary goal of the stationary axle test stand was to provide a means of determining axle efficiency as a function of lubricant in a controlled laboratory environment. Efficiency of the axle is determined through precise measurement of input power and output power of the axle during operation, with power being calculated from the measured speed and torque at the input and outputs of the axle. The mathematical ratio of input and output power represents the mechanical efficiency of the hardware, and provides a means of efficiency comparison with the gear oil remaining the independent variable.

It was desired that the stationary axle stand be constructed in a modular fashion to accommodate three axle hardware sets representative of light, medium, and heavy tactical wheeled vehicles currently fielded by the U.S. Army. The modular design was required so that each hardware set could be interchanged over the course of research, without requiring major reconfiguration to the test stand between each axle assembly. Per the contract scope of work (SOW), the following axle hardware sets were to be considered during the design of the axle stand (reference Table 1).

Table 1. Axle Efficiency Stand Suggested Hardware

Vehicle Type	Axle Location
M1074A1 PLS	#5, Rear Axle, Rear Tridem
M1083A1P2 FMTV	#3, Rear Axle, Rear Tandem
M1097A2 HMMWV	#2, Rear Differential and Wheel Hubs

The hardware procured for the test stand largely followed the original equipment of interest called out in the SOW, with the exception of the HMMWV hardware which was acquired for the

latest model up-armored equipment currently being fielded. A summary of actual procured equipment and part numbers is shown in Table 2.

Table 2. Actual Axle Hardware Procured

Vehicle Type/Model	Component Part Number
M1074A1 PLS	872131046
M1083A1 FMTV	RR15611NFDF32-780
M1151A1/52A1/65A1/67A1 HMMWV	6041984 & 6041985, geared hub 12469309, differential assembly 12460369-4, half shaft assembly

2.2 OPERATING CYCLE CONSIDERATIONS

Initial target speed and load conditions used to size equipment for the stationary axle stand were to be based on data acquired during previously conducted SAE J1321 [5] testing conducted using Family of Medium Tactical Vehicles (FTMV) [3,4], and TARDEC provided simulation data for the light and heavy tactical wheeled vehicles. Simulations for the light and heavy tactical wheeled vehicles were conducted by TARDEC following the same driving cycle used during the FMTV evaluations, so that input axle speed and torque conditions would be known for a common driving cycle for each of the three hardware sets of interest. The specific driving cycle (herein referred to as the transient cycle) was derived from a combination of two existing SAE J1376 driving cycles (local and short haul cycles), and is shown in distance versus speed format in Figure 1.

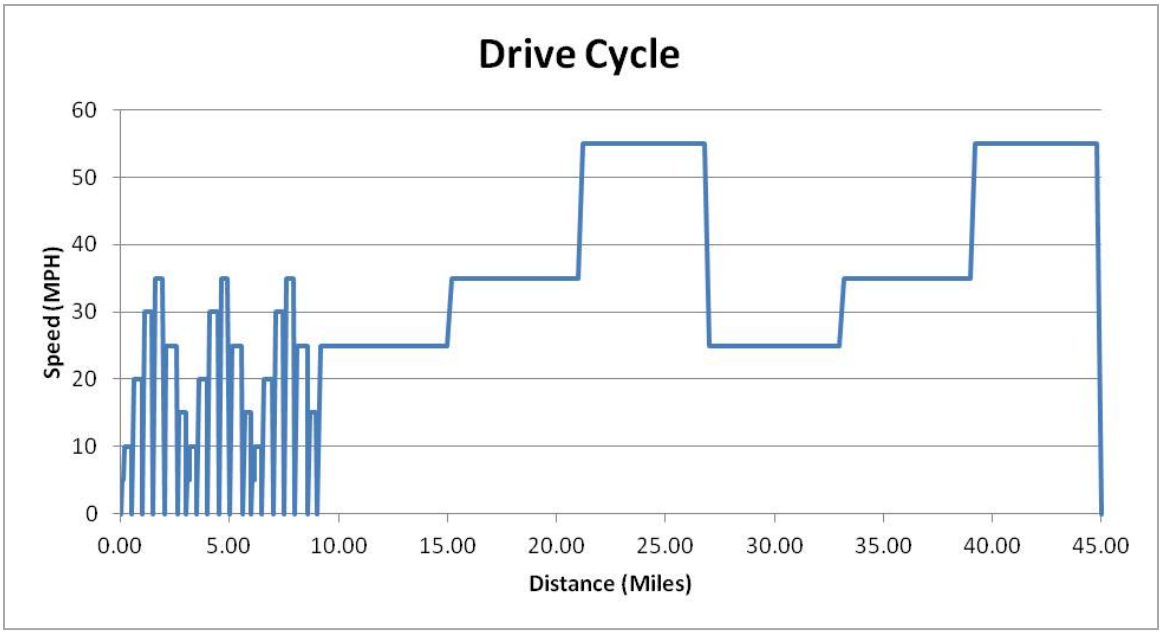

Figure 1: SAE J1321 FMTV Transient Driving Cycle Speed/Distance Plot

Although not a direct comparison, the replication of the transient cycle speed and load conditions on the stationary axle stand would allow some insight and comparison between full scale vehicle testing, which yields real world fuel consumption improvement values, to the more conceptual changes in mechanical efficiency measured on the stationary axle stand. (Note: additional full scale SAE J1321 vehicle tests using the light and heavy tactical wheeled vehicles is being conducted under follow-on work directives to compliment FMTV vehicle data.)

The following sections will cover further detail on how data was reduced from the FMTV vehicle evaluations, and the light and heavy simulations to develop speed and load requirements for the stationary axle test stand.

2.2.1 Heavy Wheeled – PLS Simulation Data Reduction

Since the full scale vehicle data was not readily available prior to the stand design, simulation data was provided by TARDEC for the PLS vehicle on the transient cycle to determine input and output axle stand speed and load conditions. The simulation data was comprised of output wheel speed, output wheel torques, and overall vehicle velocity as a function of time. To verify the simulation data against what was expected, the vehicle velocity was converted from kilometers

per hour (KPH) to miles per hour (MPH), and plotted versus distance. This was then compared to the defined transient drive cycle plot to verify that the simulation matched the expected speeds and distances of the transient cycle (Figure 2). As shown, the PLS drive cycle simulation data matched the desired transient driving cycle conditions well, with some minor variation in acceleration ramps and calculated speed (which the latter is largely a function of assumed tire diameter).

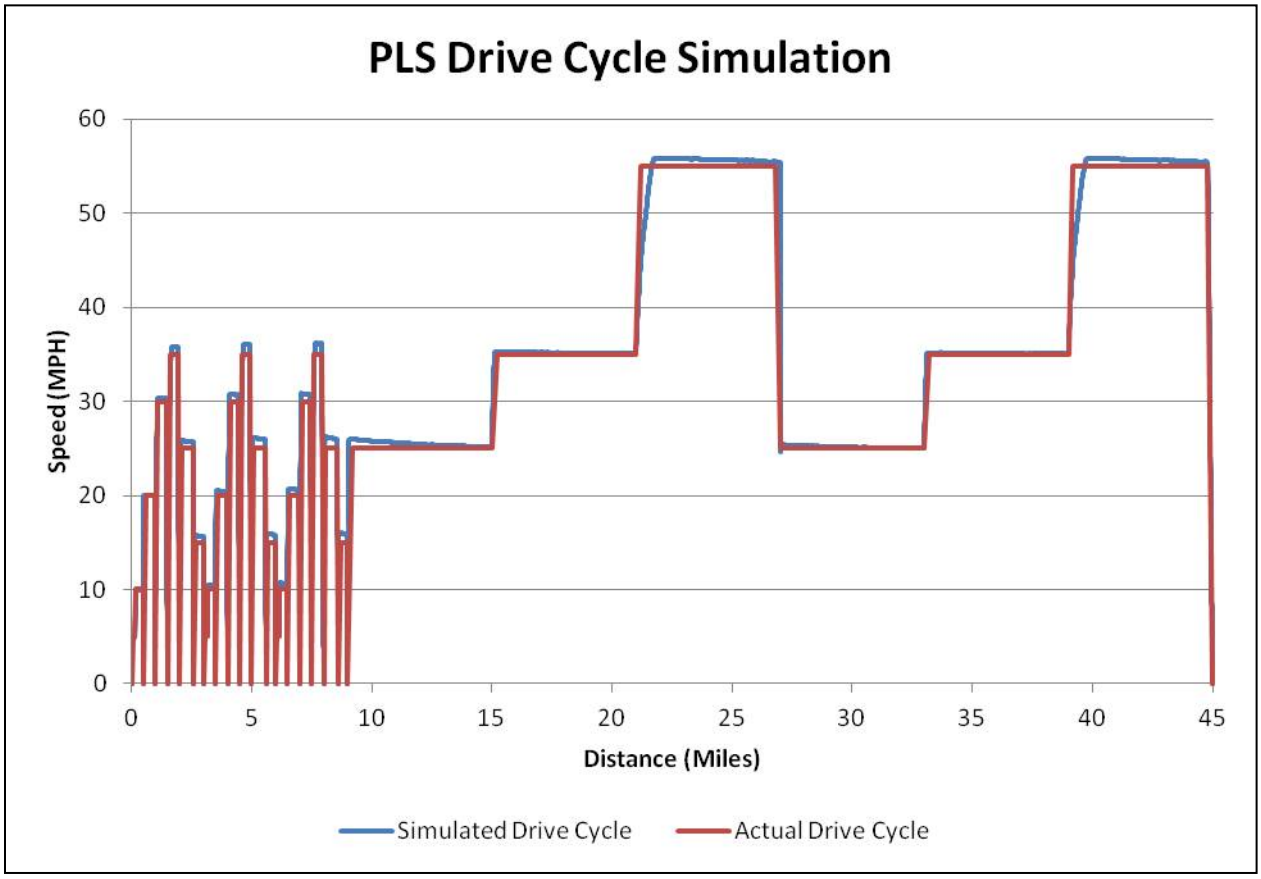

Figure 2. PLS Drive Cycle Simulation Verification

After the initial verification was conducted, attention shifted to the individual wheel speed and torque data to be used to derive input axle loading conditions for the axle stand. The three left and three right rear wheel torques from the simulation data were averaged for every time step (1 second) to calculate an average rear wheel torque over the duration of the drive cycle. This number was then multiplied by two to estimate a single total axle output torque (i.e., two wheels per axle), and then divided by the overall axle gear ratio (6:1) to determine input torque

condition. Input axle torque data was then plotted. Upon review, there were 34 input torque data points identified that were of significantly higher torque than all others. These high torques occurred during points of initial vehicle take-off, and during some gear change events, and would require special (and costly) test stand equipment to replicate on the stationary axle stand. Since these points are such short duration, and the focus for the axle stand will be primarily on steady state type conditions, these 34 data points were omitted when determining the PLS speed and load requirements. Figure 3 shows the unmodified torque points, and Figure 4 shows the modified torque points versus vehicle speed from the PLS simulation.

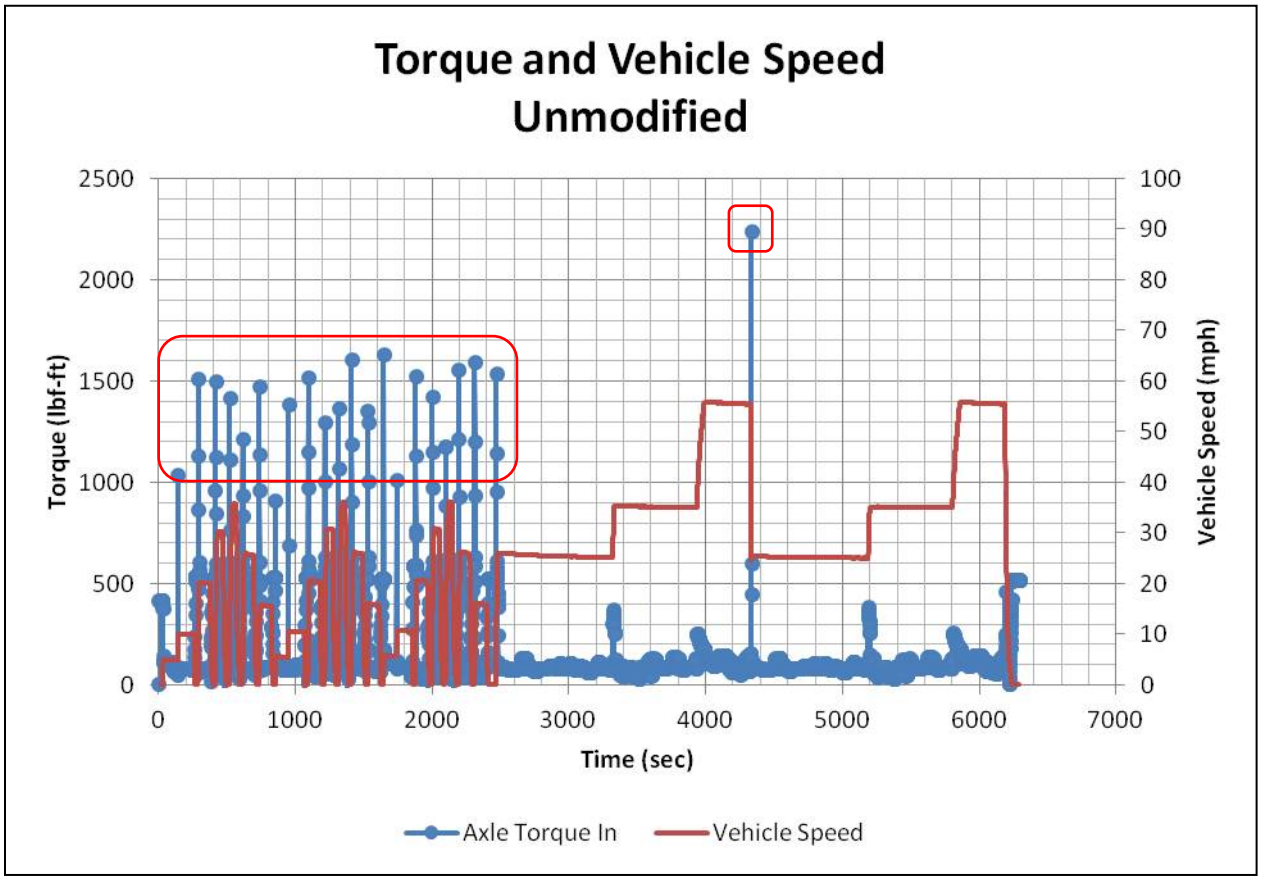

Figure 3. PLS Unmodified Input Load Conditions

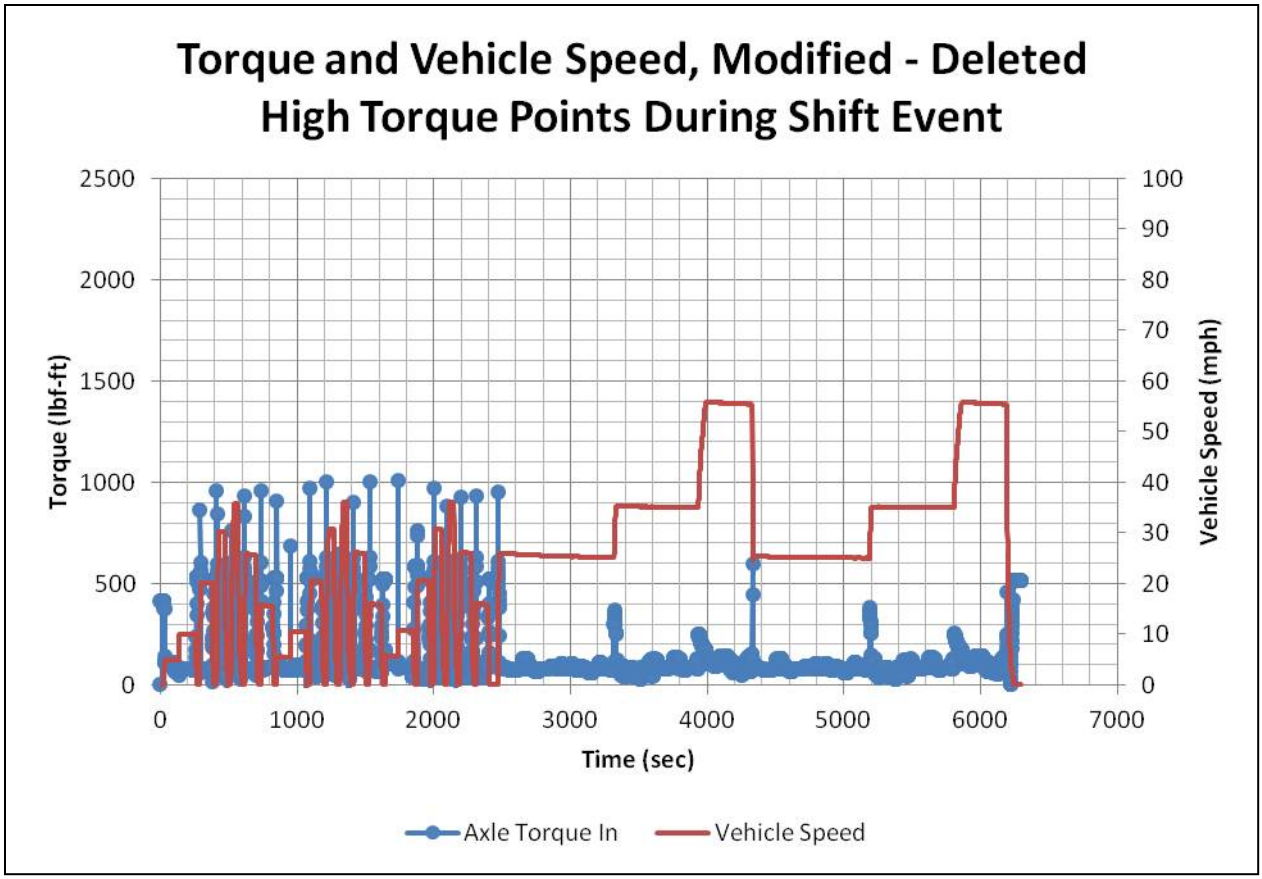

Figure 4. PLS Modified Input Load Conditions

In similar fashion to the torque calculations, the output wheel speed was multiplied by the overall axle ratio (6:1) to calculate the axle input speed (i.e., pinion speed). Using this axle input speed and the input torque calculated previously, a torque-speed curve was generated for the entire drive cycle. This curve is shown in Figure 5.

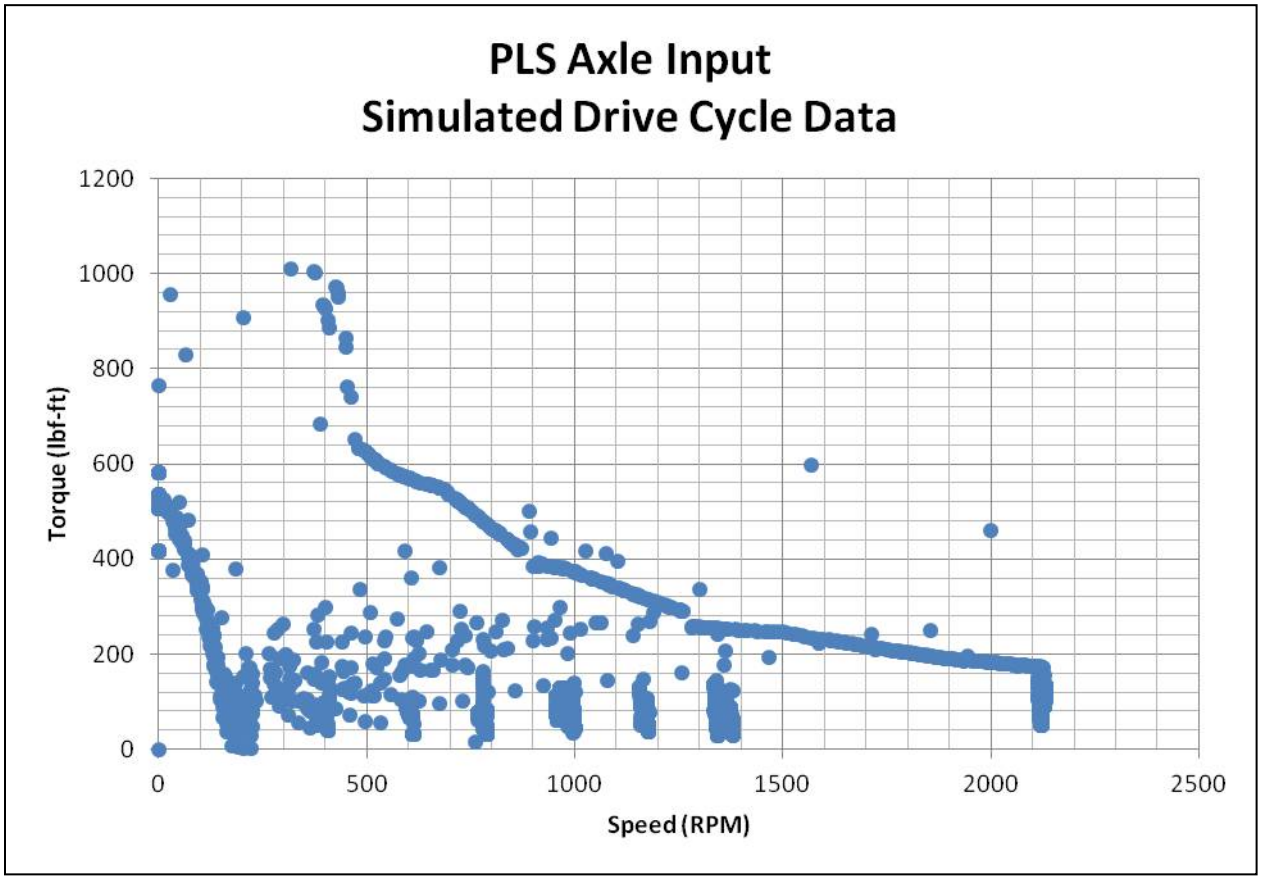

Figure 5. PLS Axle Input Torque Speed Curve

The overall axle ratio was again used to factor in the input curve to calculate the output axle torque-speed curve based on the modified input torque conditions. This is shown in Figure 6.

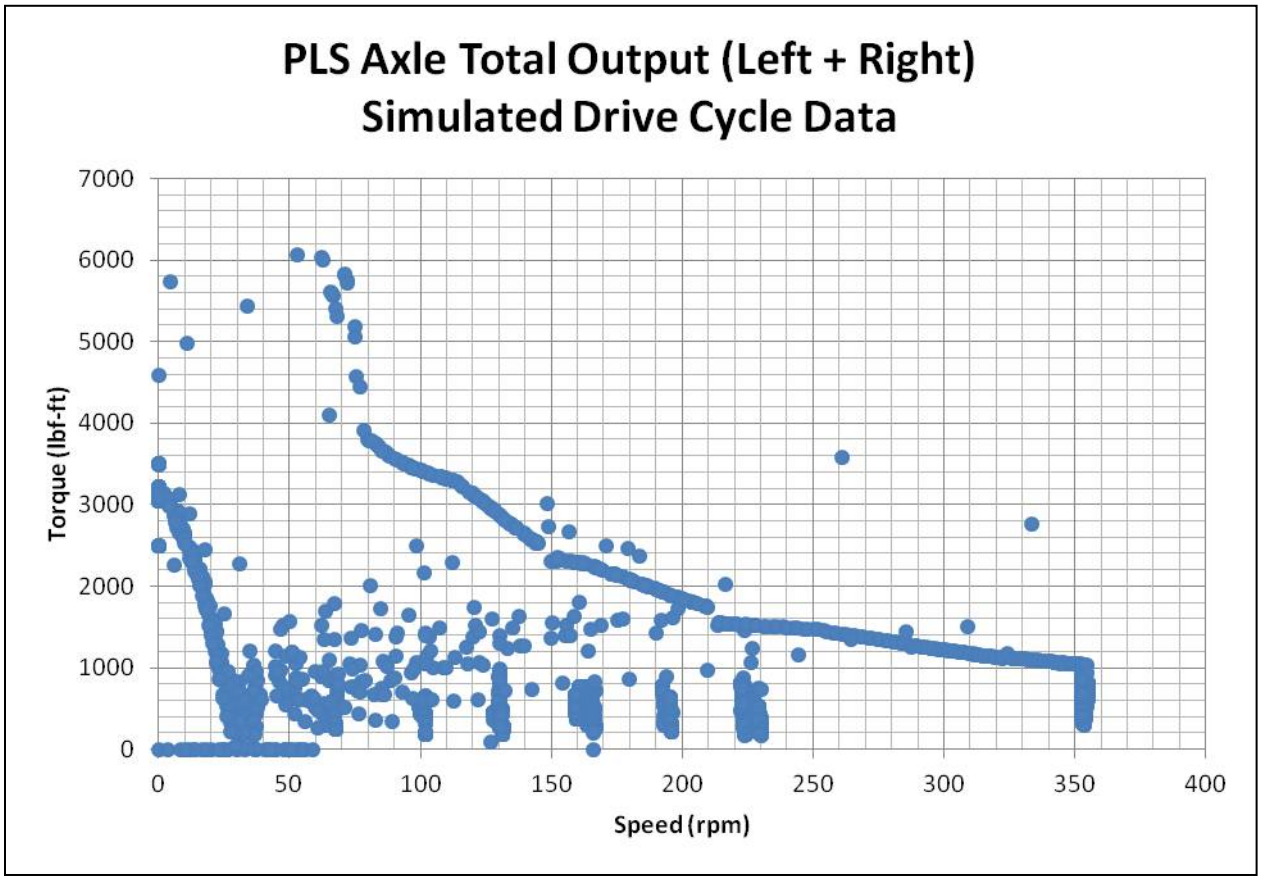

Figure 6. PLS Axle Output Torque Speed Curve

These plots were then used to help aid in equipment sizing and selection for the axle efficiency stand for the PLS axle hardware.

2.2.2 Medium Wheeled – FMTV SAE J1321 Acquired Data Reduction

For the FMTV, real world vehicle data had been previously acquired during previous SAE J1321 fuel efficiency testing when operated under the transient driving cycle [4]. Data acquired from that testing was directly used to size hardware for the axle efficiency stand. The following discusses how the data was developed from the vehicle test to define axle input and output speed and load conditions.

To determine axle input speed, the transmission output speed (which was a measured value from SAE J1939 on board data logging) was used, as the two pieces are mechanically linked by the vehicles driveshaft during operation. However the axle torque input calculations are more complicated than that of speed.

First it was determined that the #3 axle was the most appropriate axle to consider for the stationary axle stand testing. By selecting the rear most axle from the tandem, the inter-axle differential is eliminated, and the articulated ends of the front steering axle are eliminated, thus simplifying hardware installation on a stationary stand. It is known that the FMTV transfer case proportions the output power 30% to the front axle and 70% to the rear tandem, so resulting input torque to each of the rear axles can be estimated at 35% of the total torque leaving the transmission output (ignoring losses). Without instrumentation on the intermediate shaft connecting the rear tandem axles, which was outside the scope of the previous SAE J1321 test program, an estimated torque was determined based upon known Caterpillar C7 power characteristics and the acquired SAE J1939 CAN bus data. Using the “engine percent load at current speed” parameter logged (SAE J1939 SPN 92), along with past laboratory data of full load power and torque curves for the Caterpillar C7 engine powering the FMTV, the power output of the engine was estimated over each point of the transient drive cycle. From there the current gear ratio of the transmission was used to calculate the output torque leaving the transmission. The torque was then scaled by 35% to estimate the tandem rear axle input torque. The equations used to calculate this torque are shown in Figure 7.

$$HP(S) = PR(S) * HP_{max}(S)$$

Where

S = Current engine speed (rpm)
PR = Engine percent load at speed, S
HP_{max} = Maximum engine horsepower at speed, S
Derived value using third order polynomial generated from TFLRF Caterpillar C7 power curves
HP = Estimated engine horsepower at speed, S

$$T_{Engine}(S) = (HP(S) * 5252)/S$$

Where

T_{Engine} = Estimated engine torque at speed, S

$$T_{TransOut}(S) = T_{Engine}(S) * TGR$$

$$S_{TransOut}(S) = S/TG\,R$$

Where

TGR = Transmission gear ratio at speed, S
$T_{TransOut}$ = Estimated transmission output torque at speed, S
$S_{TransOut}$ = Transmission output speed at engine speed, S

$$T_{AxleIn}(S) = T_{TransOut}(S) * 35\%$$

Where

T_{AxleIn} = Single rear axle input torque at speed, S

Figure 7. FMTV Rear Axle Torque Input Calculations

The final resulting torque input to the rear axle of the vehicle is shown in Figure 8.

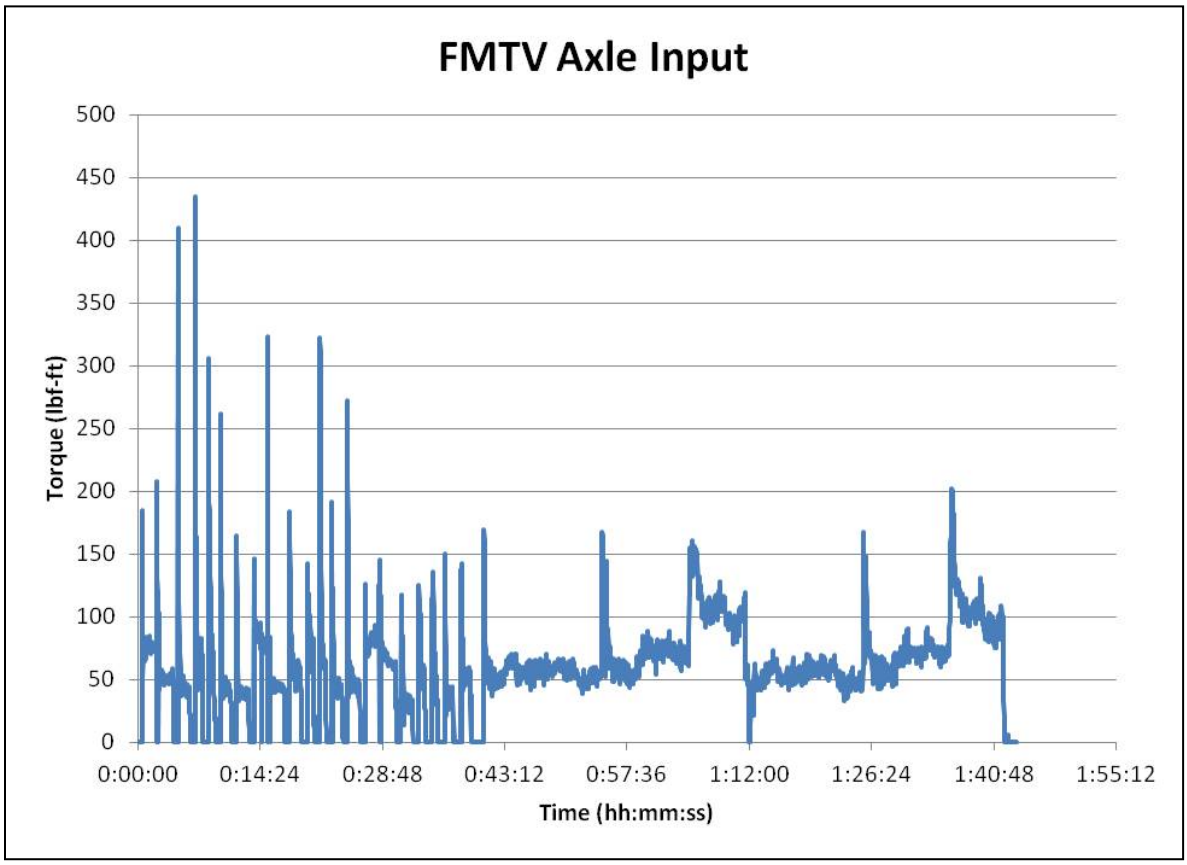

Figure 8. Plotted FMTV Rear Axle Torque Input

It should be noted that no torque multiplication factor was included in the axle input torque calculations for the stationary stand. Torque multiplication, although potentially high, occurs at high differential stator and turbine speeds within the torque convertor and reduces quickly as the vehicle attains speed. For recreating the drive cycle on the stationary stand, the focus was more on the longer duration steady state conditions, thus torque converter multiplication was omitted. This estimated input torque and the measured axle input speed (i.e., trans out speed) resulted in the axle input speed and load conditions shown in Figure 9.

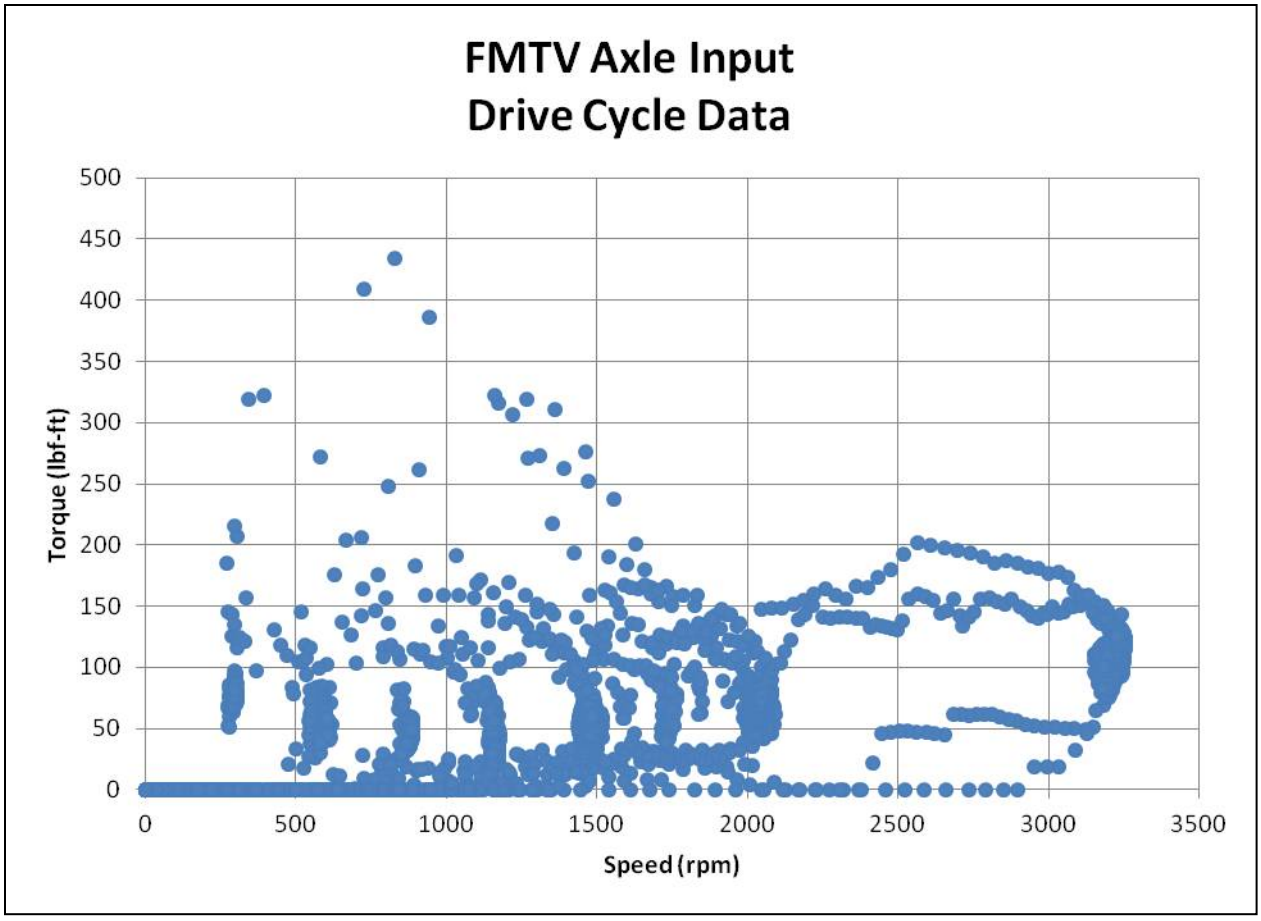

Figure 9. FMTV Rear Axle Input Torque Speed Plot

Assuming no wheel slip or differential action, the total output torque was then determined by multiplying the input torque data calculated above by the axle ratio (7.8:1), while the input speed was divided by the axle ratio (7.8:1) to calculate the output speed. This allowed the axle output torque and speed plot to be generated, as shown in Figure 10.

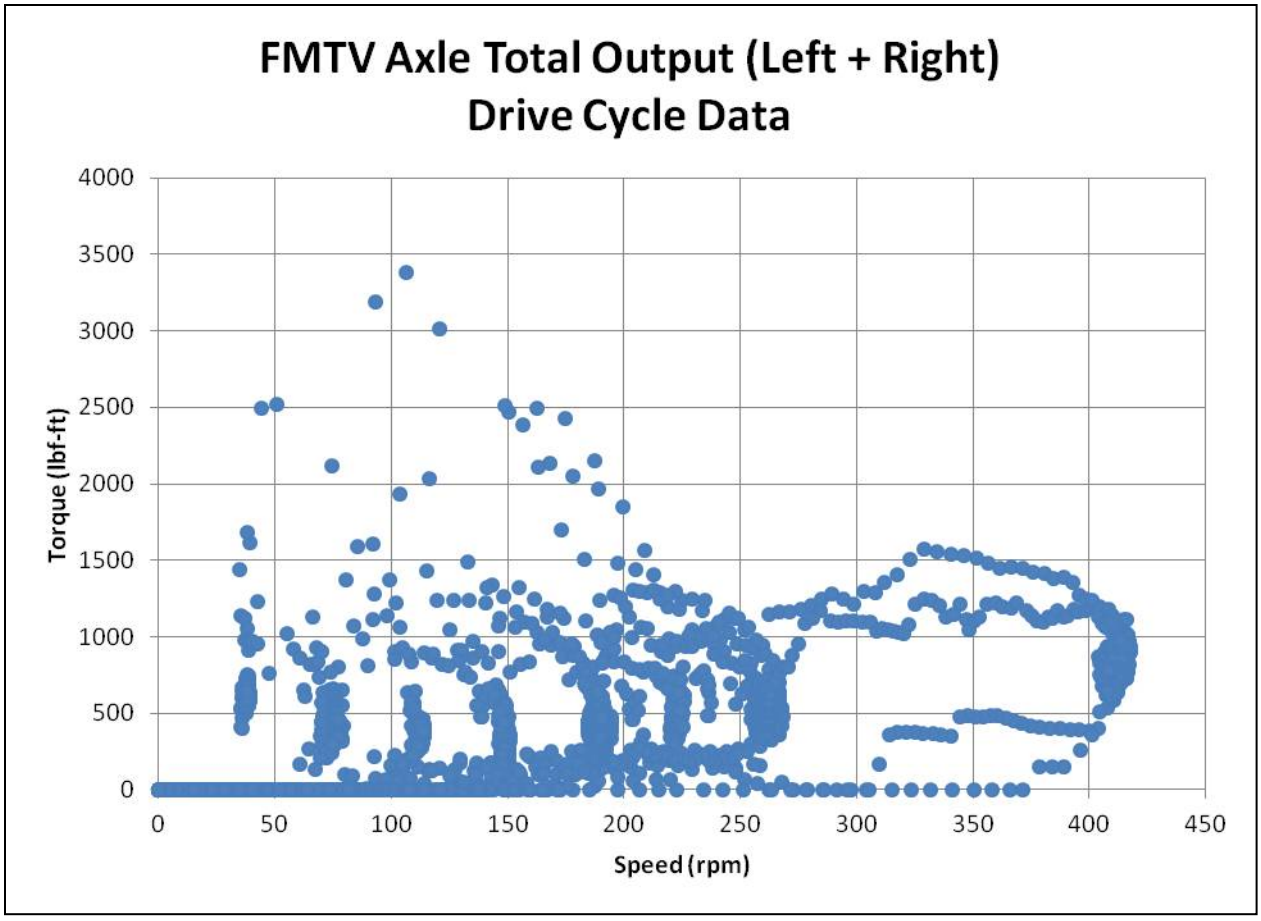

Figure 10. FMTV Rear Axle Output Torque Speed Plot

As with the PLS data, these plots were then used to help aid in equipment sizing and selection for the axle efficiency stand for the FMTV hardware.

2.2.3 HMMWV Worst Case Condition

At the time of the test stand design and component selection, neither the simulation or road test data were available. In order to ensure the test stand equipment would meet all of the functional requirements for testing the HMMWV axle, a worst case maximum load axle input torque condition was used for calculations. This was determined using a known General Engine Products (GEP) 6.5L(T) engine power curve, a torque converter multiplication of 1, a transfer case multiplication of 1.01, and known transmission gear ratios. The calculation is shown in the equation below:

$$T_{AxleIn}(S) = TC * C * T_{Engine}(S) * GR$$

Where

T_{AxleIn} = Single rear axle input torque at speed, S
S = Current engine speed (rpm)
TC = Transfer case multiplication, 1.01
C = Torque converter multiplication, 1.0
T_{Engine} = Engine output torque at speed, S
GR = Transmission gear ratio

The gear ratios used were 2.48, 1.48, 1, and 0.75. The maximum axle input torque was plotted versus speed and is shown in **Figure 11** below.

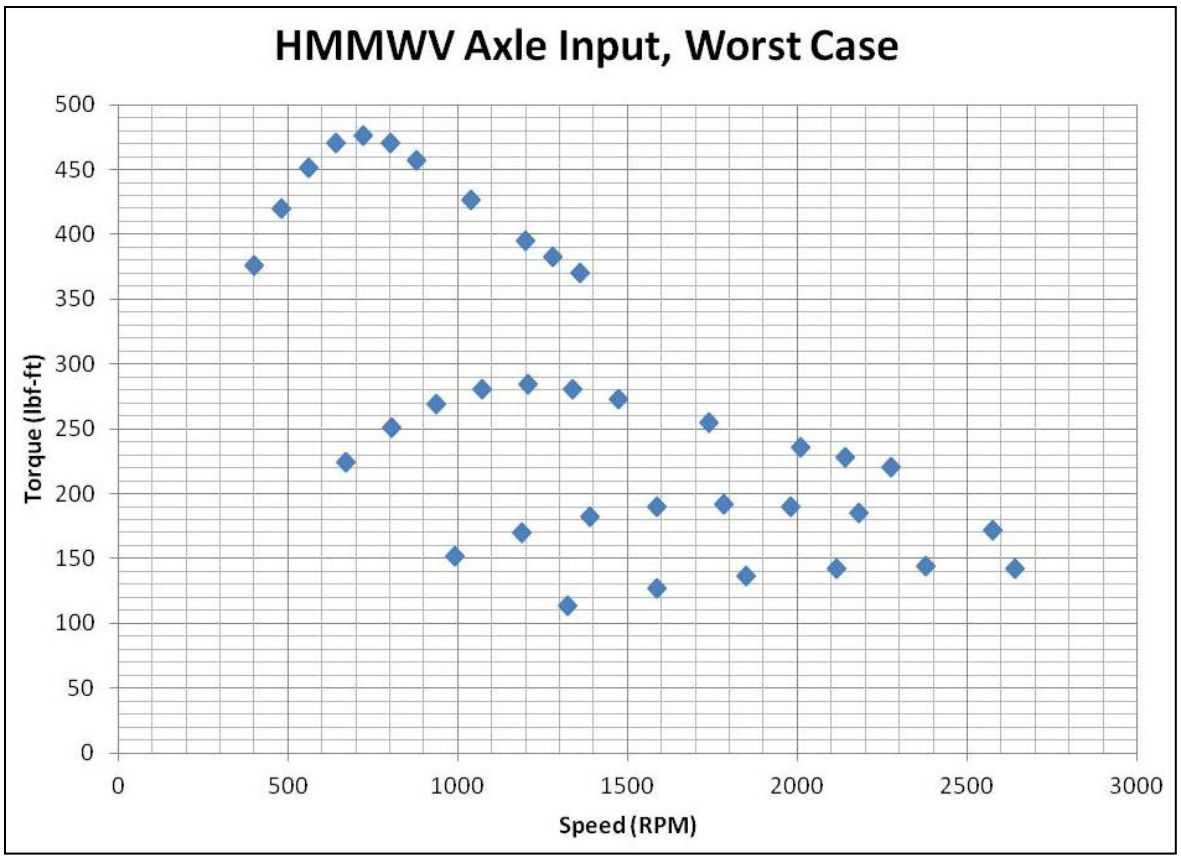

Figure 11. HMMWV Worst Case Maximum Input Torque Speed Conditions

The differential ratio of the axle is 2.73, and the wheel hub ratio is 1.92, thus the overall axle ratio is 5.24 (2.73 x 1.92 = 5.24). The input torque data calculated above was multiplied by the overall axle ratio (5.24:1) to determine the total axle output torque. The input speed was divided by the overall axle ratio to determine the axle output speed. This data was plotted versus speed and is shown in Figure 12.

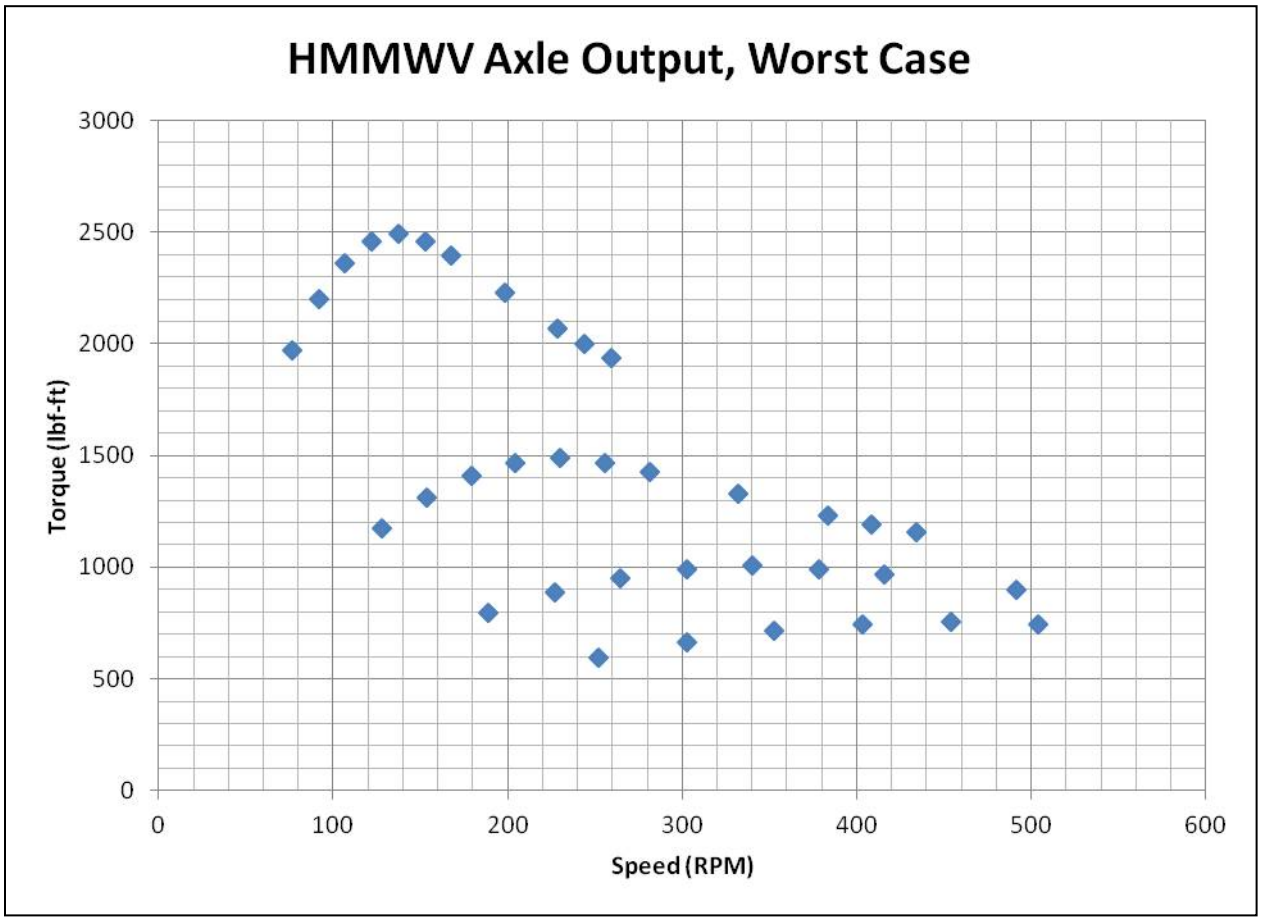

Figure 12. HMMWV Worst Case Maximum Output Torque Speed Conditions

As with the PLS and FMTV data, these plots were then used to help aid in equipment sizing and selection for the axle efficiency stand for the HMMWV hardware.

2.2.4 Combined Axle Torque – Speed Data

In order to ensure the selected stationary axle test stand equipment would meet each of the three axles of interest, the axle input and output torque-speed plots for all three vehicles were combined and plotted. These are shown in Figure 13 and Figure 14 respectively.

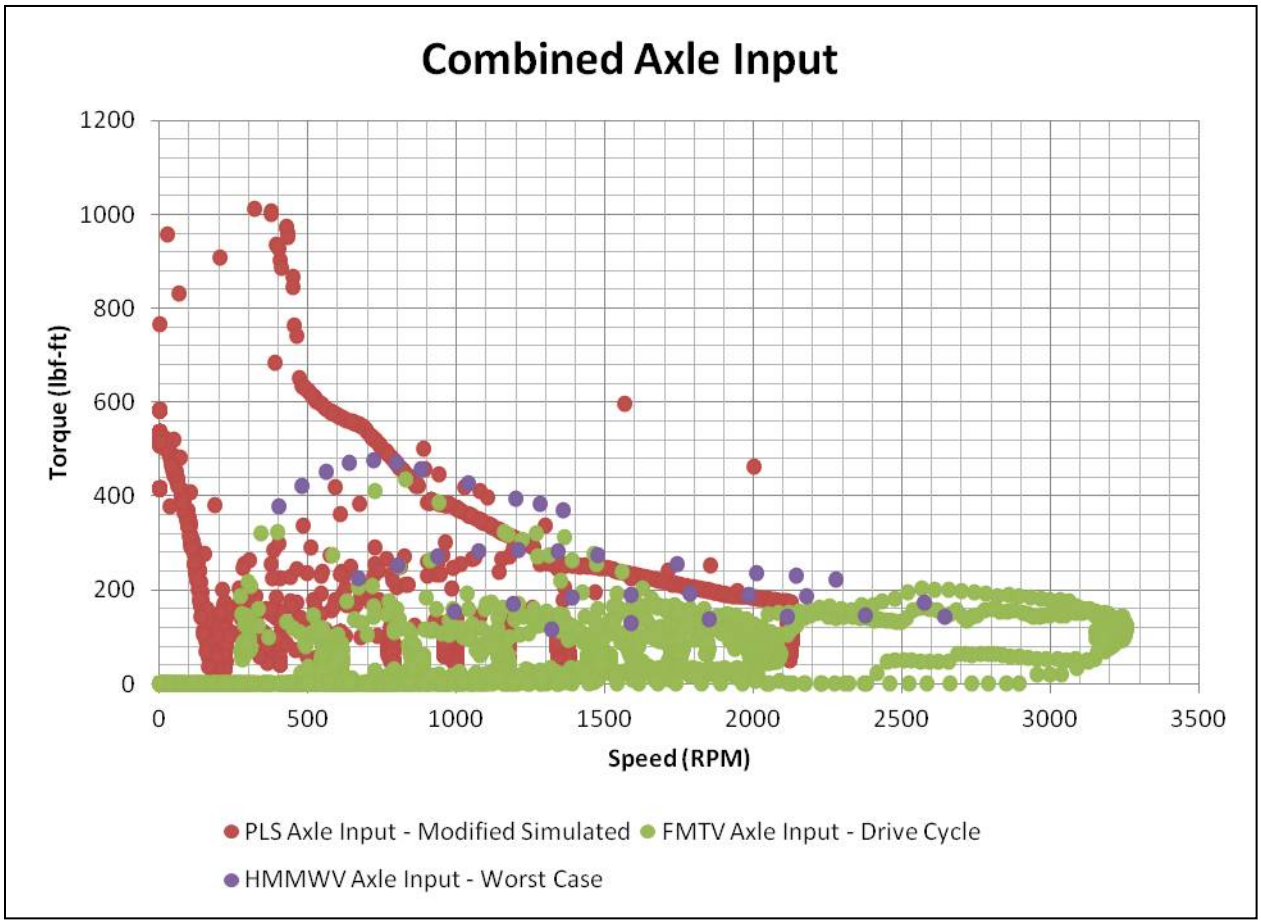

Figure 13. Combined Axle Input Speed Load Conditions

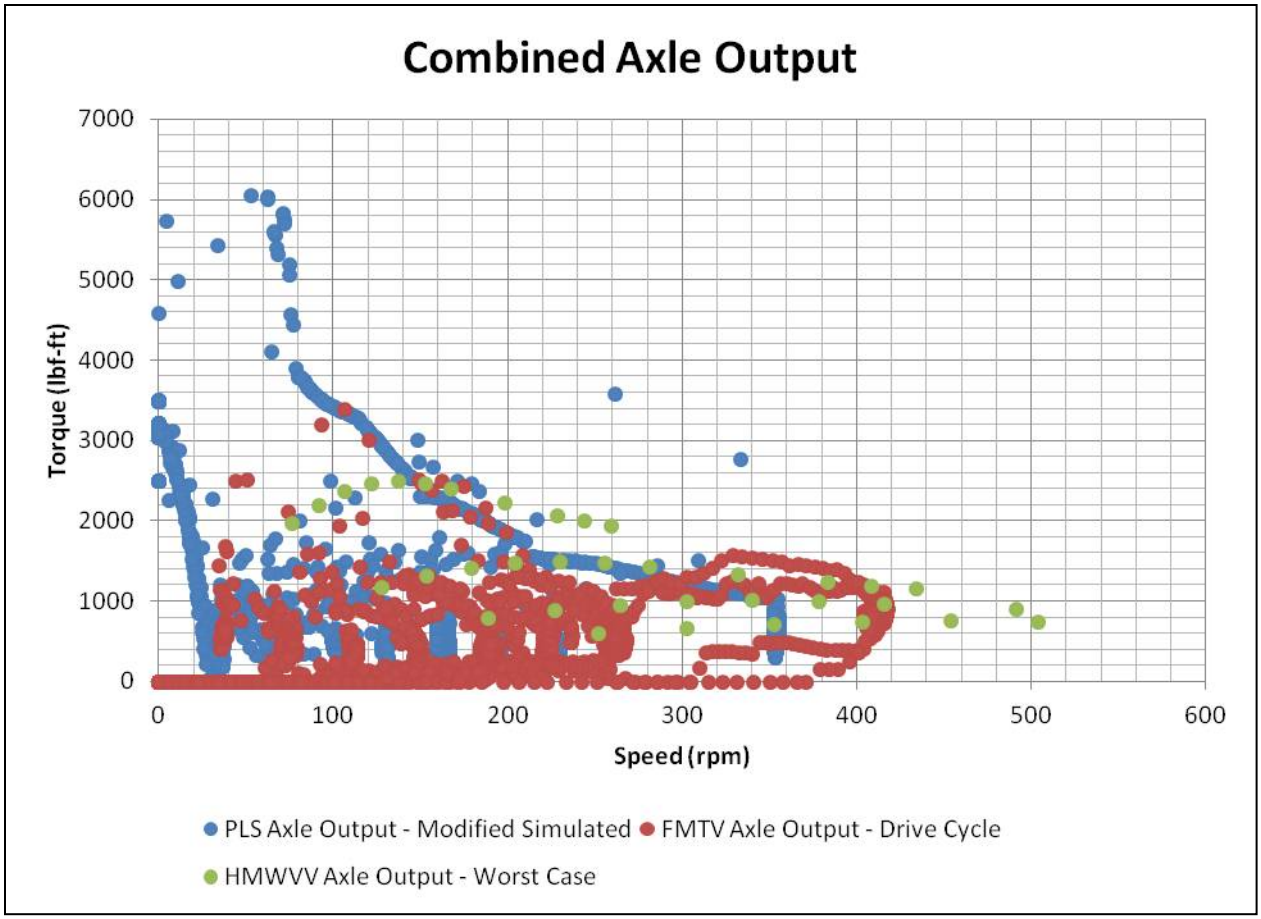

Figure 14. Combined Axle Output Speed Load Conditions

From this data, the maximum input and output axle requirements can be summarized as shown in Table 3.

Table 3. Maximum Input/Output Axle Requirements for Stand Sizing

	Axle Input	Axle Output
Maximum Speed (rpm)	3260	505
Maximum Torque (ft-lb)	1010	6060

2.3 TEST STAND COMPONENT SELECTIONS

With the input and output conditions for the stationary axle stand clearly defined, all test stand hardware could then be specified. The following sections outline the selection process and final equipment chosen for the axle stand.

2.3.1 Power Input Hardware

In order to meet the requirements of the three selected axles, the input device had to be capable of achieving at a maximum speed of 3260 rpm and a torque of 1010 ft-lb. The input device had to also be able to vary speed from 0 to 3260 rpm. The best hardware choice for this was identified as an AC motor controlled by a variable frequency drive (VFD), sized appropriately to ensure it can meet the power, torque, and speed requirements for desired hardware being tested. The torque-speed curve for an appropriately sized 250hp AC motor was added to the combined axle input torque-speed plot to demonstrate it can meet the desired requirements. This is shown in Figure 15.

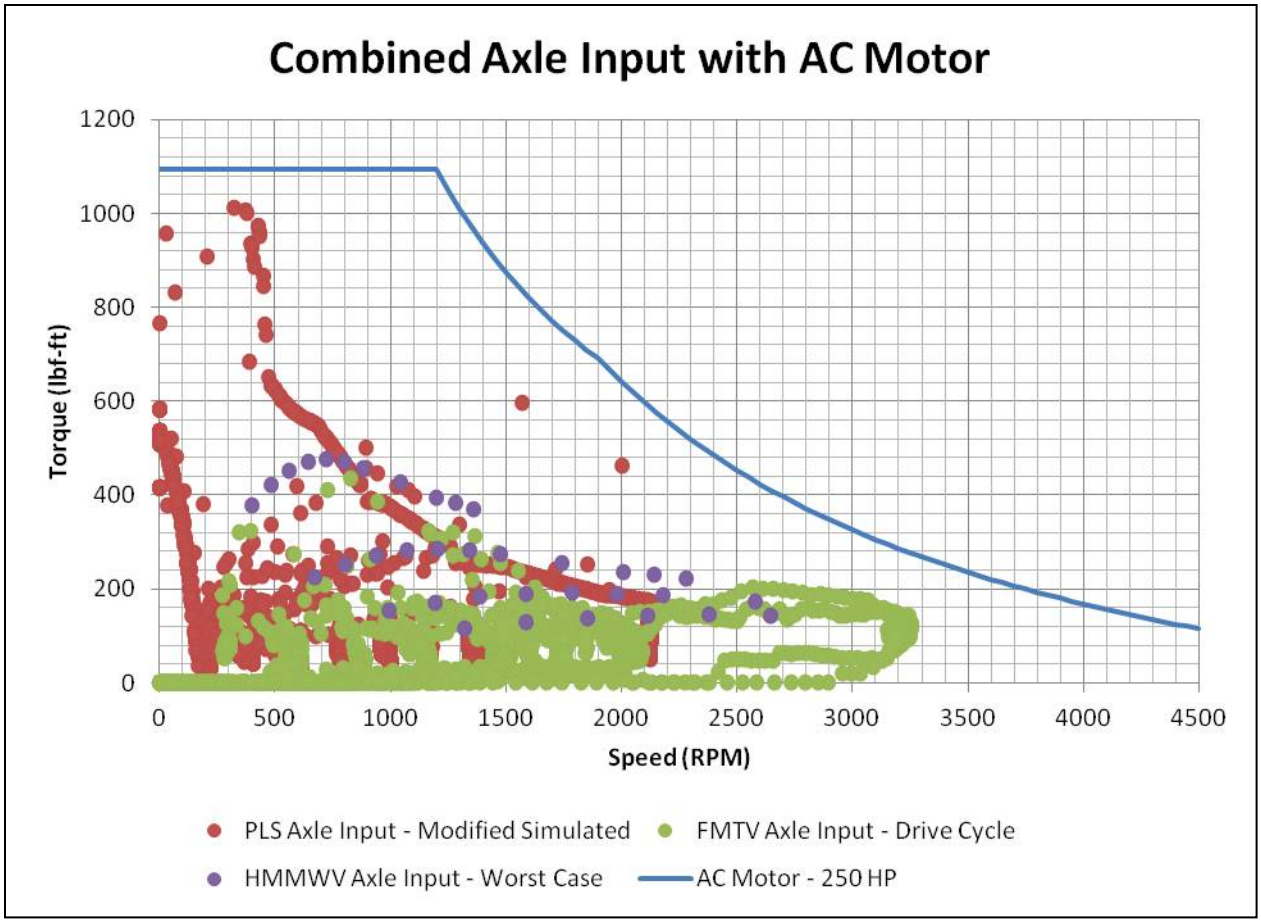

Figure 15. Input Motor Selection

2.3.2 Output Hardware

There were two different hardware requirements for the output side of the axle, a power absorber, and speed increasing/torque reducing gearboxes (with the two gearboxes being identically sized). As the gearboxes are directly coupled to the left and right axle outputs, they had to be selected based on the axle output requirements of 505 rpm and 6060 ft-lb torque. However, the total axle output torque is split approximately 50% to each side, resulting in a torque output of 3030 ft-lb per side. Thus, each gearbox must be capable of transferring 3030 ft-lb of torque. The absorbing unit was dependent on the overall gearbox ratio selected, as a lower torque reducing gearbox ratio would require a higher torque lower speed absorbing device, whereas a higher torque reducing gearbox ratio would require a lower torque higher speed absorbing device. After reviewing the different axle final drive ratios to understand the turndown ratio from the input motor speed to wheel speeds (PLS: 6, FMTV: 7.8, HMMWV: 5.24), and the

torque characteristics of each axle, an optimum gear box ratio was determined to be 7.25:1. With the gearbox ratio set, the absorbing unit could then be considered. Similar to the input device, an AC motor with a VFD could be used. An alternative solution would be to use an eddy current absorbing dynamometer. Each solution had different advantages and disadvantages summarized below:

- Eddy Current Absorber
  - Pros
    - Lower cost
    - High torque capability
  - Cons
    - Limited torque at very low speeds
    - Reduced torque control at low torque conditions
    - If water-in-gap type eddy current, water drag
    - No back driving capability
    - Required process water supply & return infrastructure
- AC Motor with VFD
  - Pros
    - Highly precise torque or speed control over entire operating range
    - Can also motor the stand (back driving capability) in addition to absorbing power
  - Cons
    - More expensive
    - More facility power required (could be offset with regenerative capability)

The torque-speed curve for both options was plotted on a modified combined axle output plot. The combined axle output plot previously presented in Figure 14 was modified to factor in the 7.25:1 increase in speed and decrease in torque when going through the gearbox. This is shown in Figure 16.

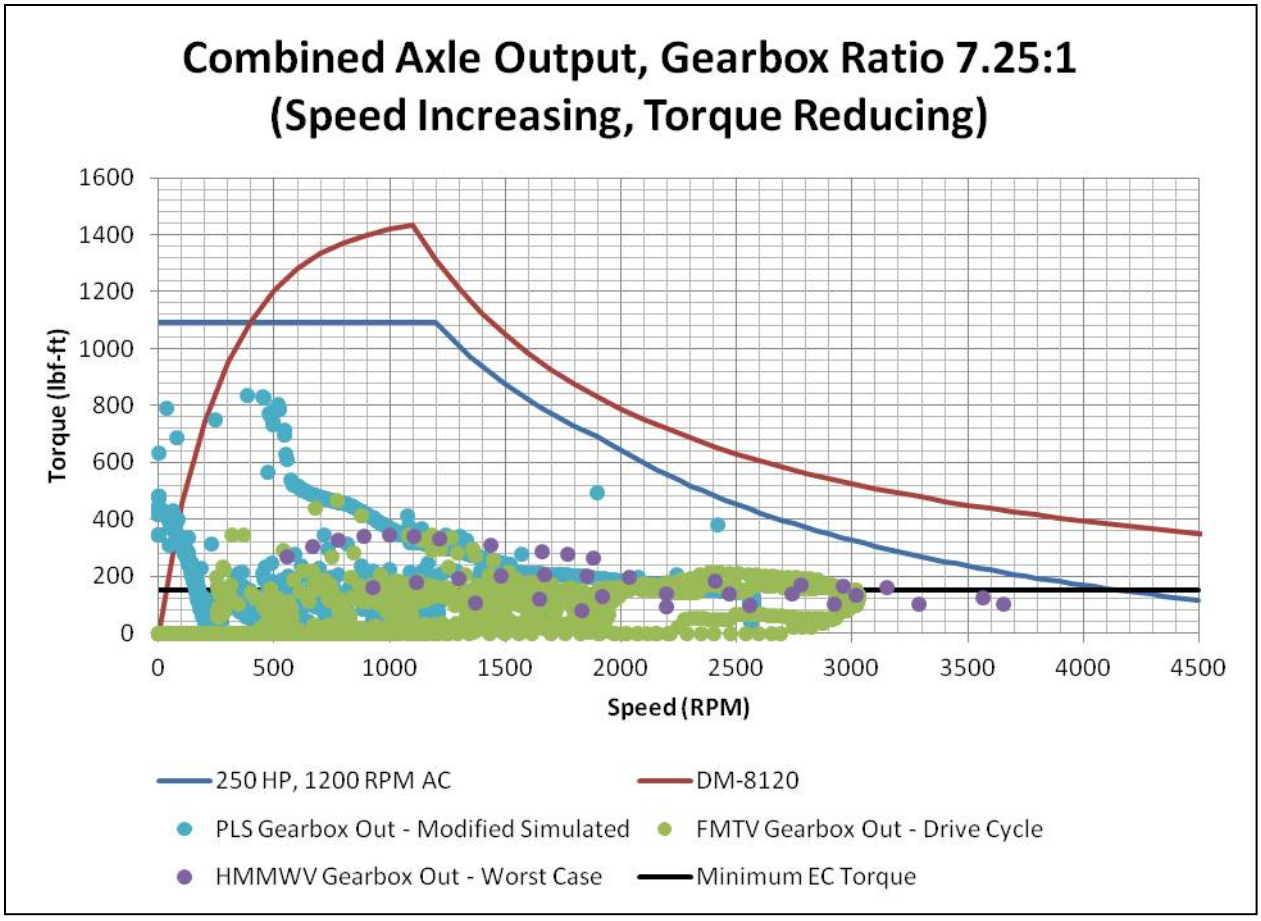

Figure 16. Combined Axle/Gearbox Out Speed Load Conditions

As shown, the eddy current dynamometer would not be capable of achieving several of the low speed high torque points required for the PLS hardware, and overall torque control would not be as stable below the minimum eddy current torque line (shown in black). Since a majority of the points fell in this less optimal control regime, and the eddy current lacked low speed torque capacity for the PLS hardware, it was determined to not be a suitable option. However the VFD controlled AC motor met all the defined axle requirements. In addition, due to the selected gearbox ratio, the absorbing motor was able to be specified as the same model as the input motor; thus simplifying the overall test stand with common components.

2.3.3 Major Component Hardware Summary

The following tables outline the major hardware components selected for the test stand, including basic specification information where applicable.

Table 4. Input/Output Motor Specifications

AC Motor	
Make	T-T Electric
Model	AMP 225-4B
Power (HP)	250(1)
Overload Power (HP)	275(2)
Base Speed (rpm)	1200
Torque (ft-lb)	1094(3)
Overload Torque (ft-lb)	1203(2)

1: Constant Power Range from 1200-1920 rpm
2: 110% Overload for 60 seconds
3: Constant Torque Range from 0-1200 rpm

Table 5. Variable Frequency Drive Specifications

Variable Frequency Drive	
Make	ABB
Model	ACS800
Input Voltage (VAC)	480
Phase	3
Input Current (Amps)	299
Input Frequency (Hz)	60
Output Voltage	480
Output Current (Amps)	316
Overload Rating (%)	110(1)

1: 110% for 60 seconds out of 300 seconds

Table 6. Gear Box Specifications

Gearbox	
Make	Lufkin
Model	M195CH
Ratio	7.259 : 1
Input Speed (rpm)	550
Power (HP)	125
Service Factor	3 (1)

1: Catalog Rating of 375 HP

Table 7. Torque Measurement Specifications

Make	HBM
Model	T40B
Description	Torque Flange
Nominal Rating	
MTV Input:	1kNm
MTV Output:	3kNm
Accuracy Class	0.05

Table 8. Speed Measurement Specifications

Make	Avtron Encoders
Model	AV850 SMARTach II
Resolution	1024 pulses/rev
Accuracy	+/- 1 pulse

2.4 TEST STAND ASSEMBLY

Upon receiving the selected equipment, the axle stand construction began. The stand was built and installed into TFLRF building 135, a recently converted storage facility that was brought up to date with infrastructure to support other Army related testing. Due to size and space limitations in B135, the original test stand concept developed during previous work [6], where the absorbing motor was located outside the gearboxes, was modified to accommodate the absorber between the gearboxes. In order to accommodate this, double reduction parallel shaft gearboxes were specified to effectively lengthen the depth of the gearbox to create additional

space behind the axle. Also, high angle driveshafts were selected to further to increase space between the absorbing motor and the axle.

To reduce the number of holes drilled into the floor of the building, a baseplate was fabricated and installed to facilitate the mounting of the test equipment. Figure 17 shows B135 prepared for test stand assembly, and Figure 18 shows the baseplate and VFDs installed.

Figure 17. Building Preparations for Stand Installation

Figure 18. Baseplate and VFD Installation

After the baseplate was installed, the absorbing motor and gearboxes were mounted on the baseplate. To provide better access around the left rear area of the baseplate, one VFD was moved into the opposite right corner behind the test stand from its original location. This is shown in Figure 19 below.

Figure 19. Modified VFD Placement, Absorber & Gearbox Placement

The absorbing motor and two gearboxes are mounted on adjustable stands referred to as elephant feet. This allows for vertical (and some horizontal) adjustment for alignment purposes; once aligned, these remain in a fixed position. Next the axle was installed on the test stand which was also on elephant feet for vertical adjustment. The axle mounts were designed to accommodate the vehicle installed pinion angle of 12.3° for the FMTV. The final mount design incorporated a two point axle mount in order to reduce axle wrap up (twist) under high load conditions. After the axle was aligned, the input motor platform was aligned and installed. This platform was designed to also use elephant feet to provide vertical adjustment capability to accommodate the three different axles. In addition, there are two bolt patterns for the motor machined to the motor platform to accommodate the horizontal variability between axle input pinion locations of the HMMWV, FMTV, and PLS. A floor mounted jib crane was installed to the main baseplate to aid in the installation and removal of the axle under test. Guards were fabricated and installed to provide protection from rotating equipment. Behind the main guards the driveshafts have an inner loop mounted to further promote safety in the event a driveshaft fails. Lastly instrumentation was installed on the stand and wired back to the PRISM console for data

acquisition and control. The test stand in its final configuration with the FMTV axle installed is shown in Figure 20.

Figure 20. Final Stand Installation Arrangement (FMTV Axle Installed)

2.5 TEST STAND SAFETY FEATURES

Special consideration was given to safety of the test stand during its design and installation phase, and includes separate focus on software based safety and hardware based safety. Each are discussed in the following sections.

2.5.1 Software Based Safety

The stationary axle test stand is controlled and monitored using the SwRI developed PRISM data acquisition and control system. This allows seamless integration with all other test stands located at TFLRF labs, and allows for remote monitoring and shut down capabilities by support staff maintained in the main engine testing facility. During operation, the PRISM control system samples all data at a frequency of 100Hz, and allows automatic triggering of programmed limits to protect the test stand, facility, and personnel from any potential hazards. The following lists the various parameters used to implement stand safety measures, and a brief description of function:

- Input Motor Speed vs. Absorber Motor Speed
    - Real time differential speed monitoring allows for detection of axle or driveline mechanical failure. Any sensed differential speed (above nominal signal noise levels) triggers automatic emergency stop, where both the input and absorbing motor brake to reduce speed to zero.
    - Protects against internal mechanical axle failure, and driveshaft failure (input driveshaft, low speed output shafts, high speed output shafts).
- Input and output torque measurement
    - Real time dynamic torque limits allow for over/under torque conditions to trigger specific stand responses.
    - Protects against internal mechanical axle failure, driveshaft failure (input driveshaft, low speed output shafts, high speed output shafts), speed increasing gear box failure, input/absorbing motor and control system failure.
- Temperature
    - Temperature monitoring of axle differential fluid, speed increasing gearbox fluid, input and absorbing motor winding and bearing temperatures.
    - Protects against internal mechanical axle failure, speed increasing gear box failure, and electrical/cooling failure of input/absorbing motor

2.5.2 Hardware Based Safety

In addition to software based safety, hardware safety measures are implemented to protect the stand, facility, and personnel from any potential hazards. Details of these are listed below:

- High speed rotating shaft guards
    - All high speed rotating shafts are contained within a 12 inch square box tubing guard to protect operations personnel from spinning equipment, and to contain small debris during the event of a shaft or universal joint failure.
- Low speed rotating shaft guards
    - All low speed rotating shafts are protected by removable wall and top panels to prevent personnel from accessing spinning equipment while providing modularity to changing axle configurations.
- Driveshaft safety loops
    - Both low and high speed rotating shafts are configured with internal drive shaft safety loops to retain the driveshaft position and limit shaft movement in the event of a shaft or universal joint failure. Each shaft is equipped with two safety loops, which should provide support at each end of the shaft where breakage could occur.
- Emergency stop interface
    - The stand is configured with two emergency stop buttons that can be quickly activated by operations personnel in the event that a quick shutdown is required. This emergency stop is independent of the automated emergency stops that the PRISM control system is capable of requesting. Personnel activation of the emergency stop button will initiate the same braked ramp down of the input and absorbing motor to zero speed as if the data acquisition system commanded it.
- Stand interlock devices
    - Multiple interlock devices are present to prevent the stand from operating if a minimum amount of system function is not verified. This includes:
        - Process water flow switch that detects cooling water to the speed increasing gearbox lubrication system.

- Low pressure lubrication switch that detects adequate lubrication pressure for the speed increasing gearboxes.
- Input/absorber motor air flow switches that detect if the motor cooling fans are active
- Emergency stop communications between the input/output motor controller interface and the PRISM data acquisition system

2.6 TEST STAND OPERATION AND REPEATABILITY ANALYSIS

After all setup and shakedown of the test stand was completed, efforts focused on establishing repeatability of the test stand using the installed FMTV axle and baseline 80W-90 oil used during the previous SAE J1321 FMTV testing [4]. The original intention of the federal test method was to base test conditions off of the same or similar conditions operated during the previous SAE J1321 testing. As a result, the same transient drive cycle data that was used to calculate input speed and load conditions for equipment sizing was again used to determine average speed and load condition for each of the maintained steady state speeds conducted during the transient cycle. When analyzing the data the primary focus was placed on steady state operation, as to remove any bias from the torque spikes associated with acceleration and deceleration transients that occurred when ramping between the different speed conditions of the drive cycle. The final speed and load targets selected for the FMTV under the transient cycle are summarized in Table 9.

Table 9. FMTV Transient Cycle Input Speed Load Conditions

Input/Pinion Conditions		
	Speed [rpm]	Load [ft-lb]
55 MPH	3207	104
35 MPH	2033	67
30 MPH	1723	66
25 MPH	1469	54
20 MPH	1157	45
15 MPH	865	45
10 MPH	684	56
5 MPH	294	80

Since the stationary stand does not have active temperature control for the axle differential fluid, the eight speed points were organized in order from highest speed to lowest speed, as that was expected to correlate to a natural decrease in fluid temperature for each of these steps. A basic testing procedure was established to create the best test to test consistency. It was as follows:

1. Stand warmed up at 3207 rpm and 150 ft-lb until axle differential fluid temperature reaches 220 °F
2. Axle is then ramped to first speed and load condition and operated until differential fluid temperature stabilization is reached
    a. Temperature stabilization is defined as <1 °F change in 60 seconds
3. A 3 minute data logging step is conducted (0.5 second log rate)
4. Axle is ramped to the next speed/load target
5. Steps 2a-4 are repeated for all speed and load conditions
    a. Operation of all speed and load points represents 1 cycle
6. Steps 1-4 repeated until 10 full cycles are complete (Approx. 15-16hrs)

Operating all tests in this manner yielded fairly consistent axle fluid temperatures run to run. Figure 21 shows a typical temperature response (by cycle) that was observed by following the above operating procedure. As shown, with the exception of cycle 1, all remaining cycles typically followed a very consistent temperature decrease from the starting warm-up temperature criteria that leads the 55 MPH step. For all runs, cycle 1 temperature was consistently low. This is a result of the entire system and room experiencing warm up during the first operational cycle. As a result, cycle 1 data was dropped from the final efficiency calculations for every run.

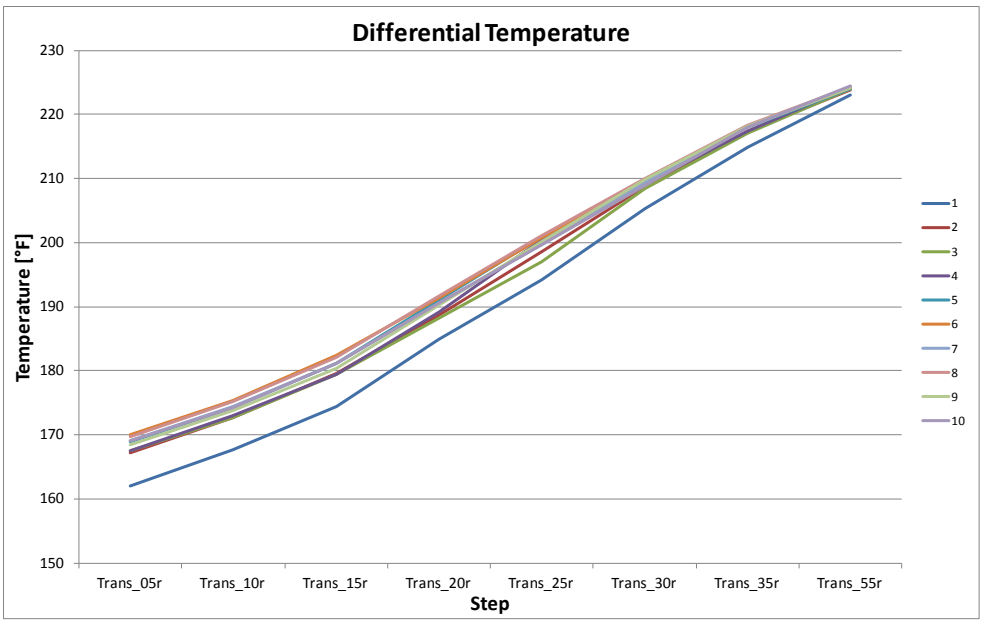

Figure 21. Typical Axle Fluid Temperature Response – FMTV Transient Cycle

For post processing of the data, the average values of speed in, speed out, torque in, and torque out left and right were calculated for each of the three minute stabilized data log steps for each speed and load condition of the transient cycle. This allowed for an individual efficiency calculation to be completed for each step and each cycle. An example of this result matrix is shown in Table 10.

Table 10. Typical Post Process Efficiency Calculations

	STEP	Cycle								
		2	3	4	5	6	7	8	9	10
150914-TransientFull	Trans_05r	94.08	94.11	94.23	94.25	94.21	94.26	94.21	94.26	94.24
	Trans_10r	93.18	93.22	93.24	93.26	93.23	93.27	93.23	93.29	93.21
	Trans_15r	91.98	92.16	92.16	92.11	92.09	92.24	92.16	92.31	92.24
	Trans_20r	91.30	91.47	91.40	91.42	91.45	91.49	91.45	91.53	91.50
	Trans_25r	91.71	91.78	91.76	91.75	91.76	91.84	91.79	91.88	91.92
	Trans_30r	92.21	92.26	92.27	92.32	92.41	92.44	92.35	92.44	92.46
	Trans_35r	91.84	91.96	91.82	91.92	91.99	92.08	92.03	92.08	92.11
	Trans_55r	92.52	92.54	92.62	92.63	92.65	92.68	92.65	92.72	92.74

From this data, each of the cycles 2-10 efficiency values were then averaged to provide a single efficiency value for each speed and load condition. An example of the averaged values can be seen in Table 11.

Table 11. Averaged Efficiency Result, by Step

Run AVG, All Cycles	
	EFF
Trans_05r	94.21
Trans_10r	93.24
Trans_15r	92.16
Trans_20r	91.45
Trans_25r	91.80
Trans_30r	92.35
Trans_35r	91.98
Trans_55r	92.64

This data was then used to plot run by run efficiency results, and can be potentially be used to calculate a single efficiency result by conducting a weighted average based on total time/distance operated on each condition for the transient cycle. A final method of reporting these values has not yet been finalized, but results for the two methods of comparison will be presented here.

Figure 22 shows the overall run to run comparison of average efficiency for each of the first five runs completed, while Table 12 shows the same data in tabular form. Runs are listed by date (YYMMDD-TransientFull). As shown, consistency in the data varies some based on the particular speed and load condition of interest. This is expected, as some combinations of speed and load will have better controllability based on the mechanical response of the system as a whole. From this preliminary data, the 25 and 20 MPH steps tended to show the most run to run variation, with a maximum difference of 0.21% and 0.29% respectively. All other operating points varied less than 0.20% from run to run.

Table 12. Repeatability Matrix #1, Tabular

	150824-TransientFull	150827-Transient Full	150825-TransientFull	150831-Transient Full	150901-TransientFull	Std Dev	Max -Min
Trans_05r	94.37	94.48	94.50	94.52	94.53	0.066	0.17
Trans_10r	93.73	93.72	93.79	93.75	93.68	0.041	0.11
Trans_15r	92.57	92.61	92.65	92.68	92.67	0.047	0.11
Trans_20r	91.80	91.91	92.01	92.01	91.96	0.088	0.21
Trans_25r	92.04	92.27	92.33	92.30	92.23	0.114	0.29
Trans_30r	92.59	92.69	92.77	92.73	92.72	0.070	0.19
Trans_35r	92.24	92.30	92.39	92.29	92.32	0.056	0.15
Trans_55r	92.78	92.85	92.90	92.81	92.85	0.045	0.12

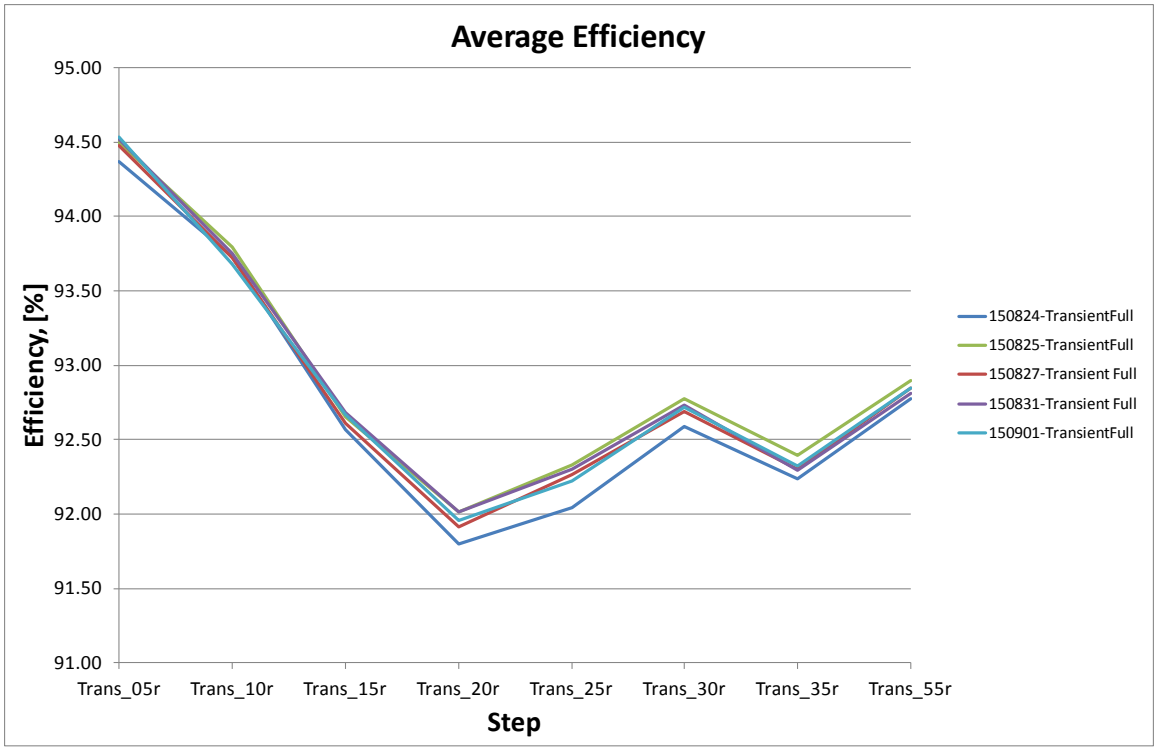

Figure 22. Repeatability Matrix #1, Plotted

The second way to compare this data is by reducing the individual step efficiencies to a single weighted efficiency result for each run. A weighting scale was established for the transient cycle based on total distance traveled at each speed and load condition, and is shown in Table 13. When applying these weightings, the calculated step efficiency for each run, can be determined as shown in Table 14. As seen here, the overall max to min variation improves some, but still approaches 0.20%.

Table 13. Transient Cycle Weighted Average Values

	Transient Cycle Weighting
Trans_05r	1.0%
Trans_10r	2.2%
Trans_15r	2.9%
Trans_20r	3.3%
Trans_25r	31.4%
Trans_30r	3.1%
Trans_35r	29.9%
Trans_55r	26.2%

Table 14. Transient Cycle Weighted Efficiency Result

	150824-TransientFull	150827-Transient Full	150825-TransientFull	150831-Transient Full	150901-TransientFull	Std Dev	Max -Min
Transient Cycle Weighted	92.38	92.49	92.56	92.50	92.49	0.067	0.19

It is unknown at this time what range of efficiency change is expected to be seen on the axle stand when using the oils that showed changes in the actual vehicle testing conducted with the FMTV. Although there are known results that show some percentage improvement or detriment in fuel economy from the vehicle testing, there is not yet an established relationship to the actual efficiency result generated by the stand. As such, it is currently unknown if the run to run variation observed in the initial repeatability baseline tests would obscure the changes in

efficiency we should expect to see with the candidate oils. Further investigation of this will be conducted under follow on work which will begin to run candidate oils for comparison.

When considering overall repeatability of the stand, several other key points stand out. Active temperature control has the potential to improve the run to run variation, as the typical observed temperature distribution showed separation in the overall stabilized temperature as the speed and load conditions ramped down. Although the starting 55 MPH step typically achieved run to run temperatures within 1-2 °F consistently, as the speeds ramped down during testing, this increased to approximately 4-6 °F overall. Industry research suggests that the oil sump temperature control during efficiency evaluations is critical for achieving repeatable results, and can be as important as the control of input speed and torque itself [7]. Implementation of temperature control will be addressed during the follow-on work directive.

The second item to consider for repeatability is the load targets themselves. While the targets selected for the initial repeatability testing represent the actual data recorded during the transient driving cycle conducted during the SAE J1321 testing, the overall load targets are much lower than the torques that the axle itself is designed for, and what would likely be expected to be seen during other operational modes. The highest load target in the FMTV transient cycle matrix is 104 ft-lb. This is largely attributed to the fact that focus is only being placed on steady state operation, and the final drive ratio of the FMTV (7.8:1) provides substantial mechanical advantage to the drive train. Thus, despite the SAE J1321 testing being conducted at full weighted GVWR, input torque required to maintain speed on the flat roadway remains relatively low. From internal discussions with SwRI driveline researchers, it was stated that the resulting efficiency and repeatability of the measurement generally increases when the loads are higher versus light load conditions. Incorporating additional higher load conditions and consolidating some of the low load conditions should be considered moving forward with the test method development.

Third, overall data acquisition capabilities must be considered when looking at stand repeatability. Some adjustments to the data acquisition and control system were already completed early in the program to improve the data quality and repeatability, but there are

potential further enhancements that can be made to improve results. Although digital torque meters such as the ones used on the Army stationary axle stand offer high accuracy, the combination of torque meter accuracy and signal handling effect the repeatability of results. Further adjustments to the control system and signal measurement gate times will be explored in effort to improve test stand consistency.

Lastly, it is worth mentioning the dynamic nature of the axle itself. In general, the design life for these axles is very high, and working with new hardware on the test stand, break-in effects are observed (and should be expected) throughout operation. In addition, as tested conditions change to new or different speed and load conditions, it has been advised that additional break-in can occur after previously seeing typically consistent data. This was confirmed after conducting some short duration preliminary high torque testing, and then going back and re-running an additional 5 run repeatability matrix. Table 15 and Figure 23 present the efficiency results from the second repeatability matrix completed in tabular and plotted form respectively. When compared to the previous repeatability matrix, overall efficiency tended to decrease for all points, and run to run variation increased slightly.

Table 15. Repeatability Matrix #2, Tabular

	150914-TransientFull	150915-TransientFull	150921-TransientFull	150922-TransientFull	150923-TransientFull	Std Dev	Max -Min
Trans_05r	94.21	94.27	94.22	94.27	94.31	0.044	0.11
Trans_10r	93.24	93.35	93.19	93.21	93.28	0.067	0.17
Trans_15r	92.16	92.31	92.15	92.25	92.37	0.094	0.21
Trans_20r	91.45	91.62	91.44	91.59	91.68	0.108	0.24
Trans_25r	91.80	91.95	91.83	91.98	92.11	0.125	0.31
Trans_30r	92.35	92.50	92.40	92.51	92.64	0.112	0.29
Trans_35r	91.98	92.09	91.97	92.10	92.22	0.100	0.24
Trans_55r	92.64	92.70	92.62	92.67	92.77	0.059	0.15

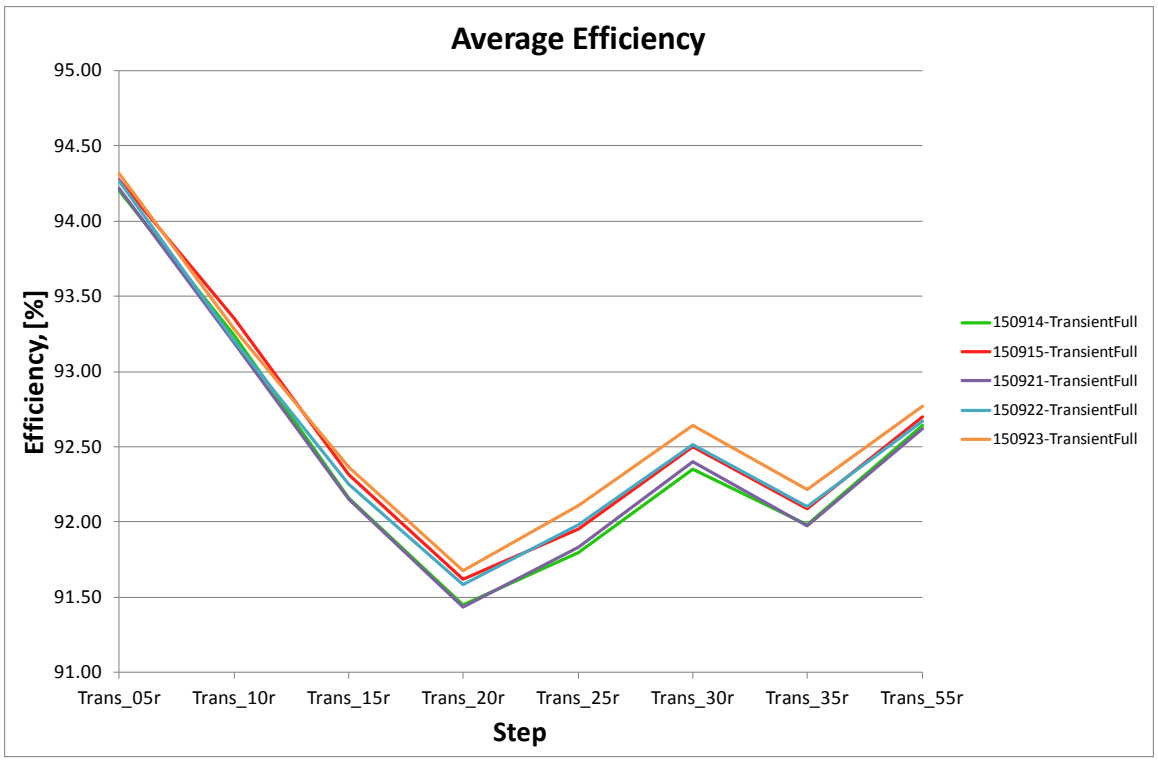

Figure 23. Repeatability Matrix #2, Plotted

Similarly, when the weighted average was applied to the second repeatability matrix runs (Table 16), we again see a slightly larger variation overall.

Table 16. Transient Cycle Weighted Efficiency Result

	150914-TransientFull	150915-TransientFull	150921-TransientFull	150922-TransientFull	150923-TransientFull	Std Dev	Max -Min
Transient Cycle Weighted	92.15	92.26	92.15	92.26	92.37	0.094	0.23

These second repeatability matrix results reinforces the previously mentioned considerations discussed regarding overall test stand repeatability. All of these areas will be further investigated under the follow-on work directive as additional testing and test development is conducted.

3.0 SURVEY OF FUEL EFFICIENT GEAR OILS

An industry survey was conducted to determine the availability of axle lubricants that claimed fuel efficiency enhancing performance. Axle lubricants and related gear lubricants are defined by the following industry specifications:

- ASTM D7450 *Standard Specification for Performance of Rear Axle Gear Lubricants Intended for API Category GL-5 Service*
- SAE J306 *Surface Vehicle Standard Automotive Gear Lubricant Viscosity Classification*
- SAE J2360 *Surface Vehicle Standard Lubricating Oil, Gear Multipurpose (Metric) Military Use*
- ASTM D5760 *Standard Specification for Performance of Manual Transmission Gear Lubricants*

None of these specifications provide guidance for defining fuel efficiency benefits from axle lubricants.

3.1 DISCUSSION OF AXLE LUBRICANTS

As stated under SAE J2360, gear lubricants with the following viscosity grades: 75W-90, 80W-90, and 85W-140, have been adopted for use by the U.S. Military. The following other viscosity grade products are also qualified to SAE J2360: 75W-80, 75W-85, 75W-110, 75W-140, 80W-110, and 80W-140.

Axle lubricants are formulated from petroleum and/or synthetic base stocks, performance additives and viscosity modifiers. Lubricant viscosity is a key property that affects oil related efficiency. A less viscous oil produces less viscous drag such as oil churning and pumping loss. Insufficient lubricant film from less viscous oil can result in higher friction and wear between component surfaces, and negatively impact efficiency.

The qualified products listing for SAE J2360 was reviewed (Appendix A). Judging from the number of qualified products listed for each company, the following companies are major

entities to consider: Lubrizol (67), Afton (67) and BASF Corp (19). No specific listings are made for products claiming to be fuel efficient, however some of the lubricants contain FE in their brand name.

An Approved Lubricant Suppliers List (March 2015) prepared by Dana Spicer Drive Train Products was reviewed. Dana approved axle lubricants are classified by their intended use. Specification SHAES 256 Rev C is for drive axle line haul service, and SHAES 429 is for drive axle vocational service.

Line haul service (on-highway) is defined as:

- High mileage operation (over 60,000 miles/year)
- On-highway or good to excellent concrete or asphalt road
- Usually more than 30 miles between start and stop
- Extended lube drain interval (500,000 miles) with SHAES 256 Rev C approved products

Vocational service is defined as:

- Low mileage operation (under 60,000 miles/year)
- Off-highway or areas of unstable or loose unimproved road surfaces
- Typically less than 30 miles between start and stop
- Extended lube drain interval (180,000 miles or three years) with SHAES 256 Rev C or SHAES 429 approved products

For the DANA approved lubricant suppliers list for the United States, 14 oils were identified in as being fuel efficient. All of the axle lubricants identified as being fuel efficient were formulated with synthetic base stocks and were SAE viscosity 75W-90.

A brief internet search was made to identify commercially available fuel efficient gear oils. A summary of the results is presented in Table 17.

Table 17. Commercially Available Fuel Efficiency Gear Oils

COMMERCIALLY AVAILABLE FUEL EFFICIENT GEAR OILS (FEGO)				
Manufacturer	**Product Name**	**Weight**	**Efficiency Claim**	**Notes**
Eaton	Roadranger FE	75W-90	1% plus improvement - Industry and fleet testing methods	
BASF	Emgard FE	75W-90	1% plus improvement - Industry and fleet testing methods	Fuel efficient, Extreme pressure (EP)
Cenex	Maxtron Enviro-EDGE GL	75W-90	1% plus improvement	
Fleetrite (Navistar	Fleetrite Synthetic FE	75W-90	1% plus improvement - Industry and fleet testing methods	
Valvoline	Syn Gard FE	75W-90	Provides measureable gains in fuel economy	
Shell	Spirax S6 AXRME	75W-90	Over 1% in both standard industry and commercial fleet testing	
Mobil	Syn Gear Lube LS	75W-90	Improved Fuel Economy	
Kendall (Phillips)	SHP Syngear FE	75W-90	1 - 1.5% fuel savings compared to typical synthetic SAE 75W-90	

The technical data sheets for the products listed in Table 17 are presented in Appendix B. The list of products in Table 17 is not all inclusive and should be considered as representative of commercially available fuel efficient gear oils.

Overall, the commercially available fuel efficient gear oils claim to provide a 1 to 1.5% improvement in fuel efficiency,

4.0 CONCLUSION AND RECOMMENDATIONS

With the physical completion of the stationary axle stand and installation of the FMTV axle hardware, in depth analysis can now be conducted on test stand axle efficiency and how it relates to overall vehicle efficiency, as well as providing a lower cost means for future fuel efficient gear oil candidate evaluations with the development of a federal test method. In addition, the modular design of the test stand lends itself to be adaptable to other hardware sets, and will support desired HMMWV and PLS axle testing to compliment other full scale vehicle testing that is being conducted and is planned. First round developmental data demonstrates that the setup and control system is capable of repeatable and consistent input speed and load control, and calculated efficiency results show the current resulting consistency. From this data, several recommendations can be made to further enhance and develop the axle stand:

1. Implement differential temperature control and determine test repeatability improvement
2. Investigate data acquisition torque measurement gate time changes on resolution and repeatability of measurement

3. Conduct current transient testing using known candidate oils from FMTV SAE J1321 testing to determine magnitude of expected efficiency change as a function of the lubricant.
4. Investigate the incorporation of higher torque load points, and their impact on efficiency results and repeatability.
5. Once basic federal test method procedure is developed using FMTV hardware, install and test HMMWV and PLS hardware
    a. Could change based on full scale vehicle test results

All of these items are expected to continue under the follow on work directive already under contract with TFLRF.

5.0 REFERENCES

1. Brandt, A.C., et. Al., “Single Common Powertrain Lubricant Development,” Interim Report TFLRF No. 418, January 2012.
2. Brandt, A.C., et. Al., “Single Common Powertrain Lubricant Development Part 2,” Draft Interim Report TFLRF No. 442, May 2014.
3. Warden, R.W., Frame, E.A., Brandt, A. C., “SAE J1321 Testing Using M1083A1 FMTVS”, Interim Report TFLRF No. 404, March 2010.
4. Warden, R.W., Frame, E.A., Interim Report TFLRF No. 444, “Axle Lubricant Efficiency”, May 2014
5. Fuel Consumption Test Procedure – Type II, SAE J1321, 2012
6. Brandt, A.C., et. Al., “Laboratory Based Axle Lubricant Efficiency Evaluation,” Interim Report TFLRF No. 459, July 2014
7. Anderson, N., and Maddock, D., 2008, “Development of a Standardized Axle Efficiency Test Methodology,” “2nd CTI Symposium”, Automotive Transmissions, North America.

APPENDIX A.

Qualified Products Listing for SAE J2360

PERFORMANCE REVIEW INSTITUTE
LUBRICANT REVIEW INSTITUTE QUALIFIED PRODUCTS LIST

Notice: The LRI Gear Oil Review Committee has reviewed the submitted test results and hardware against the performance requirements of SAE J2360 standard. It is the opinion of the Committee that based upon the information provided to them, these lubricants would be expected to meet the performance requirements of that standard.

SAE J2360 Lubricating Oil, Gear Multipurpose (Metric) Military Use

Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-May-15	PRI GL 0401	EYR-2831-H-01	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-May-15	PRI GL 0402	EYR-2831-G-01	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-15	PRI GL 0405	GO-13145	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-15	PRI GL 0406	GO-13146	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-15	PRI GL 0407	GO-13104	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-15	PRI GL 0408	GO-13143	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-15	PRI GL 0409	GO-12957	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-15	PRI GL 0410	GO-12958	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Jul-15	PRI GL 0411	GO-12093	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Jul-15	PRI GL 0412	GO-13122	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Jul-15	PRI GL 0413	GO-13161	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-15	PRI GL 0439	GO-13187	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-15	PRI GL 0440	GO-13197	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-15	PRI GL 0441	GOR-116-AN	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-15	PRI GL 0442	R09-2507	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-15	PRI GL 0376	GO-13070	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-15	PRI GL 0377	GO-11730	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-16	PRI GL 0462	GO-9744	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Apr-16	PRI GL 0468	GO-11840	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Apr-16	PRI GL 0469	GO-11841	SAE 80W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-16	PRI GL 0479	GO-13358	SAE 85W-140

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-16	PRI GL 0480	GO-13357	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-17	PRI GL 0511	GO-13444-1501	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-17	PRI GL 0512	GO-13484	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-17	PRI GL 0513	GO-12686-1001	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-17	PRI GL 0514	GO-13443	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Aug-17	PRI GL 0527	GO-12684-1006	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Aug-17	PRI GL 0528	GO-12684-1101	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Aug-17	PRI GL 0529	GO-13533	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Nov-17	PRI GL 0544	GOR-407 (R11-1498)	SAE 75W-85
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	28-Feb-18	PRI GL 0551	GO-13655-0000	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	28-Feb-18	PRI GL 0552	GO-13670-0000	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	28-Feb-18	PRI GL 0553	GO-13669-0000	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	28-Feb-18	PRI GL 0554	GO-13587-0002	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Apr-18	PRI GL 0562	GO-13656-0000	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-18	PRI GL 0576a	GO-8448	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-18	PRI GL 0577	GO-13734	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-18	PRI GL 0578	GO-12897	SAE 80W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-18	PRI GL 0579	GO-13725	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-18	PRI GL 0580	GO-13718	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-18	PRI GL 0581	GO-13717	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-18	PRI GL 0608	GO-12937-0000	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Sep-18	PRI GL 0609	GO-12938-0000	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-19	PRI GL 0642	EYR-4050AE	SAE 80W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-19	PRI GL 0643	EYR-4050AL	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-19	PRI GL 0644	GO-13901	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	30-Jun-19	PRI GL 0645	GO-13893	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0664	GO-13918-0000	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0665	GO-13919-0000	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0666	GOR-607-AF-03	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0667	GO-13061-0005	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0668	GO-13064-0003	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0669	GO-13059-0002	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0670	GO-13063-007	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0671	GO-13062-0005	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0672	GO-13065-0002	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Oct-19	PRI GL 0673	GO-13078-0001	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Dec-19	PRI GL 0694	GOR-607-AU-00	SAE 75W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0707	GO-14070-0000	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0708	GO-14071-0000	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0709	GO-14031-0000	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0710	GO-13085-0002	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0711	GO-13060-0012	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0712	GO-12957-0005	SAE 80W-90
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0713	GO-12958-0003	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0714	GO-12920-0006	SAE 85W-140
Afton Chemical Corporation	500 Spring Street Richmond, Virginia 23219 USA	31-Mar-20	PRI GL 0715	R14-18414T	SAE 80W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Allegheny Petroleum Products Company	999 Airbrake Avenue Wilmerding, Pennsylvania 15148 USA	31-Aug-17	PRI GL 0516	Altra MIL3 80W-90	SAE 80W-90
Allegheny Petroleum Products Company	999 Airbrake Avenue Wilmerding, Pennsylvania 15148 USA	31-Aug-17	PRI GL 0517	Altra MIL3 85W-140	SAE 85W-140
Allegheny Petroleum Products Company	999 Airbrake Avenue Wilmerding, Pennsylvania 15148 USA	30-Jun-18	PRI GL 0593	Altra MIL4 80W-90 LS	SAE 80W-90
Allegheny Petroleum Products Company	999 Airbrake Avenue Wilmerding, Pennsylvania 15148 USA	30-Jun-19	PRI GL 0652	Altra MIL 5 80W-90	SAE 80W-90
Allegheny Petroleum Products Company	999 Airbrake Avenue Wilmerding, Pennsylvania 15148 USA	30-Jun-19	PRI GL 0653	Altra MIL 5 85W-140	SAE 85W-140
American Refining Group, Inc.	77 North Kendall Avenue Bradford, Pennsylvania 16701 USA	28-Feb-20	PRI GL 0696	ARG Multi Purpose Gear Oil 80W-90	SAE 80W-90
Aral AG	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Sep-18	PRI GL 0636	Aral Getriebeöl SNA-E 75W-90	SAE 75W-90
Ashland Inc.	3499 Blazer Parkway Lexington, Kentucky 40512-1400 USA	31-Oct-15	PRI GL 0445	Valvoline High Performance Gear Oil	SAE 80W-90
Ashland Inc.	3499 Blazer Parkway Lexington, Kentucky 40512-1400 USA	30-Jun-17	PRI GL 0523	Valvoline Heavy Duty Gear Oil 80W90	SAE 80W-90
Beijing Tongyi Petroleum Chemical Company Ltd. **SEE Shell Tongyi (Beijing) Petroleum Chemical Company, Ltd.**					
BASF Corporation (Formerly Cognis Corporation)	4900 Este Avenue Cincinnati, Ohio 45232-1419 USA	31-Aug-16	PRI GL 0477	Emgard FE 75W-110	SAE 75W-110
BASF Corporation (Formerly Cognis Corporation)	4900 Este Avenue Cincinnati, Ohio 45232-1419 USA	31-Oct-16	PRI GL 0481	Emgard EP 75W-90 Gear Lubricant	SAE 75W-90
BASF Corporation (Formerly Cognis Corporation)	100 Park Avenue Florham Park, New Jersey 07932 USA	31-Oct-17	PRI GL 0533	Emgard 80W-140 Synthetic Gear Lubricant	SAE 80W-140
BASF Corporation (Formerly Cognis Corporation)	100 Park Avenue Florham Park, New Jersey 07932 USA	31-Mar-20	PRI GL 0704	Emgard FE 75W-90	SAE 75W-90
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	30-Jun-18	PRI GL 0572	Emgard HP 75W-90	SAE 75W-90
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	30-Jun-18	PRI GL 0573	Emgard EP 75W-90	SAE 75W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	30-Jun-18	PRI GL 0574	Emgard FE 75W-90	SAE 75W-90
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	30-Jun-18	PRI GL 0575	Emgard EP 80W-140	SAE 80W-140
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Aug-18	PRI GL 0596	Emgard XFE 75W-85	SAE 75W-85
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Aug-18	PRI GL 0597	Emgard XFE 75W-90	SAE 75W-90
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Aug-18	PRI GL 0598	Emgard XFE 75W-110	SAE 75W-110
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Aug-19	PRI GL 0654	Emgard Life Plus 80W-110	SAE 80W-110
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Aug-19	PRI GL 0655	Emgard Life Plus 80W-90	SAE 80W-90
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Aug-19	PRI GL 0656	Emgard Life Plus 80W-140	SAE 80W-140
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Dec-19	PRI GL 0690	Emgard FE 75W-90	SAE 75W-90
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Dec-19	PRI GL 0691	Emgard FE 75W-90	SAE 75W-90
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Dec-19	PRI GL 0692	Emgard HP 75W-80	SAE 75W-80
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Dec-19	PRI GL 0693	Emgard HP 75W-85	SAE 75W-85
BASF Corporation (Formerly Cognis Corporation)	500 White Plains Road Tarrytown, New York 10591 USA	31-Mar-20	PRI GL 0705	Emgard XFE 75W-80	SAE 75W-80
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	28-Feb-18	PRI GL 0563	Castrol AP Gear 80W-90 / Castrol Axle AP 80W-90	SAE 80W-90
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	28-Feb-18	PRI GL 0564	Castrol AP Gear 80W-90 / Castrol Axle AP 80W-90	SAE 80W-90
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	28-Feb-18	PRI GL 0565	Castrol AP Gear 85W-140 / Castrol Axle AP 85W-140	SAE 85W-140

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	30-Apr-18	PRI GL 0567	Castrol AP Gear 85W-140 / Castrol Axle AP 85W-140	SAE 85W-140
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	31-Oct-18	PRI GL 0617	Castrol AP Gear Lubricant 80W-90	SAE 80W-90
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	31-Oct-18	PRI GL 0618	Castrol AP Gear Lubricant 85W-140	SAE 85W-140
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	30-Jun-18	PRI GL 0688	Syngear 75W-90 / Syntrax E 75W-90	SAE 75W-90
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	30-Jun-18	PRI GL 0689	Syngear 80W-140 / Syntrax E 80W-140	SAE 80W-140
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	31-Mar-20	PRI GL 0723	Castrol AP Gear 80W-90/Castro Axle AP 80W-90	SAE 80W-90
BP Lubricants USA Inc.	1500 Valley Road Wayne, New Jersey 07470 USA	31-Mar-20	PRI GL 0724	Castrol AP Gear 85W-140 / Castrol Axle AP 85W-140	SAE 85W-140
BP plc	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Sep-18	PRI GL 0637	BP Energear SHX-M 75W-90	SAE 75W-90
Balmer Lawrie & Company, Ltd.	SBU: Greases & Lubricants P-43 Hide Road Extension Koklata - 700088, India	31-Jul-15	PRI GL 0599	Balmerol HP 85W140 SPL(J)	SAE 85W-140
Brad Penn Lubricants, LLC	801 Edwards Drive Lebanon, Indiana 46052	28-Feb-20	PRI GL 0726	Brad Penn Multi-Purpose Gear Oil 80W-90	SAE 80W-90
Castrol Ltd.	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Jun-15	PRI GL 0427	Castrol Axle AP 85W-140	SAE 85W-140
Castrol Ltd.	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Jun-15	PRI GL 0566	BP Hypogear 80W90	SAE 80W-90
Castrol Ltd.	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Jun-15	PRI GL 0603	BP Hypogear 85W-140	SAE 85W-140
Castrol Ltd.	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Jun-16	PRI GL 0492	Castrol Axle AP 85W-140	SAE 85W-140
Castrol Ltd.	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Jun-17	PRI GL 0518	Castrol Axle First Fill 85W-140	SAE 85W-140

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Castrol Ltd.	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Jun-17	PRI GL 0604	Castrol Axle AP 85W-140	SAE 85W-140
Castrol Ltd.	Technology Centre Whitchurch Hill, Pangbourne Reading, Berkshire RG8 7QR, United Kingdom	30-Sep-18	PRI GL 0638	Castrol Syntrax Universal Plus 75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Jul-16	PRI GL 0475	New Name: Delo Syn-Gear XDM SAE 75W-90 Old Name: Delo Synthetic Gear Lubricant SAE 75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Oct-16	PRI GL 0482	New Name: Delo Syn-Gear HD SAE 75W-90 Old Name: Chevron RPM Synthetic Gear Lubricant SAE75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Oct-16	PRI GL 0483	New Name: Delo Syn-Gear HD SAE 75W-90 Old Name: Chevron RPM Synthetic Gear Lubricant SAE75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Mar-17	PRI GL 0503	New Name: Delo Syn-Gear XDM SAE 80W-140 Old Name: Chevron Delo Synthetic Gear Lubricant SAE 80W-140	SAE 80W-140
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Mar-17	PRI GL 0504	New Name: Delo Syn-Gear XDM SAE 80W-140 Old Name: Chevron Delo Synthetic Gear Lubricant SAE 80W-140	SAE 80W-140
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Mar-17	PRI GL 0505	New Name: Delo Syn-Gear XDM SAE 75W-90 Old Name: Chevron Delo Synthetic Gear Lubricant SAE 75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Mar-17	PRI GL 0506	New Name: Delo Syn-Gear HD SAE 75W-90 Old Name: Chevron RPM Synthetic Gear Lubricant SAE 75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Dec-17	PRI GL 0545	Chevron Delo Gear Lubricant ESI SAE 85W-140	SAE 85W-140
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Dec-17	PRI GL 0546	Chevron Delo Gear Lubricant ESI SAE 80-90	SAE 80W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Mar-17	PRI GL 0614	Texaco Syn-Star GL SAE 75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	30-Sep-18	PRI GL 0620	Multigear S 75W-90	SAE 75W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	30-Apr-19	PRI GL 0640	Multigear EP-5 SAE 80W-90	SAE 80W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	30-Nov-19	PRI GL 0687	Multigear EP-5 SAE 85W-140	SAE 85W-140
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	30-Nov-19	PRI GL 0695	Multigear Premium EP SAE 85W-140	SAE 85W-140

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	31-Mar-20	PRI GL 0720	Thuban GL5 EP SAE 80W-90	SAE 80W-90
Chevron Products Company	100 Chevron Way, Room 71-7350 Richmond, California 94802 USA	30-Nov-19	PRI GL 0725	thuban GL5 EP SAE 85W-140	SAE 85W-140
Cognis Corporation	4900 Este Avenue Cincinnati, Ohio 45232-1419 USA	31-Jan-16	PRI GL 0459	Emgard 75W-90 High Performance Gear Lubricant	SAE 75W-90
ConocoPhillips Company	As of May 1, 2012 - See Phillips 66				
Deltaven S.A.	Planta Distribucion PDVSA Yagua Via Variante Barbula Distribuidor Yagua Valencia Estado Carabobo Venezuela	31-Jul-15	PRI GL 0428	Translub EP	SAE 80W-90
Deltaven S.A.	Planta Distribucion PDVSA Yagua Via Variante Barbula Distribuidor Yagua Valencia Estado Carabobo Venezuela	31-Jul-15	PRI GL 0429	Translub EP	SAE 85W-140
ExxonMobil Chemical Company	BTEC East Room 1466 4500 Bayway Drive Baytown, Texas 77520-2127 USA	31-Jul-15	PRI GL 0697	Mobilad PS 163 75W-90	SAE 75W-90
ExxonMobil Chemical Company	BTEC East Room 1466 4500 Bayway Drive Baytown, Texas 77520-2127 USA	31-Jul-15	PRI GL 0698	Mobilad PS 163 80W-140	SAE 80W-140
ExxonMobil Oil Corporation	3225 Gallows Road Fairfax, Virginia 22037 USA	31-Jul-15	PRI GL 0423	Mobil Delvac Synthetic Gear Oil 75W-90 NEW NAME: Mobil Delvac 1 Gear Oil 75W-90	SAE 75W-90
ExxonMobil Oil Corporation	3225 Gallows Road Fairfax, Virginia 22037 USA	31-Jul-15	PRI GL 0424	Mobil Delvac Synthetic Gear Oil 80W-140 NEW NAME: Mobil Delvac 1 Gear Oil 80W-140	SAE 80W-140
ExxonMobil Oil Corporation	3225 Gallows Road Fairfax, Virginia 22037 USA	31-Oct-16	PRI GL 0508	Mobilube 1 SHC 75W-90	SAE 75W-90
ExxonMobil Oil Corporation	600 Billingsport Road Paulsboro, New Jersey 08066 USA	30-Nov-17	PRI GL 0550	Mobil Delvac 1 Gear Oil FE 75W85	SAE 75W-85
ExxonMobil Oil Corporation	600 Billingsport Road Paulsboro, New Jersey 08066 USA	31-Jul-18	PRI GL 0610	Mobilube HD Plus 80W-90	SAE 80W-90
ExxonMobil Oil Corporation	600 Billingsport Road Paulsboro, New Jersey 08066 USA	31-Jul-18	PRI GL 0611	Mobilube HD Plus 85W-140	SAE 85W-140
ExxonMobil Oil Corporation	600 Billingsport Road Paulsboro, New Jersey 08066 USA	31-Jul-18	PRI GL 0612	Mobilube HD Plus 80W-90	SAE 80W-90
ExxonMobil Oil Corporation	600 Billingsport Road Paulsboro, New Jersey 08066 USA	31-Jul-18	PRI GL 0613	Mobilube HD Plus 85W-140	SAE 85W-140
ExxonMobil Oil Corporation	600 Billingsport Road Paulsboro, New Jersey 08066 USA	31-Jul-19	PRI GL 0657	Mobilube HD Plus 80W-90	SAE 80W-90
ExxonMobil Oil Corporation	600 Billingsport Road Paulsboro, New Jersey 08066 USA	31-Jul-19	PRI GL 0658	Mobilube HD Plus 85W-140	SAE 85W-140
Fuchs Petrolub AG	Friesenheimer Straβe 17 68169 Mannheim, Germany	30-Sep-15	PRI GL 0497	Titan Cytrac RR SAE 75W-90	SAE 75W-90
Fuchs Lubricants (UK) Plc	New Century Street, Hanley Stoke-on-Trent, ST1 5HU United Kingdom	31-Mar-18	PRI GL 0583	OEP 220	SAE 80W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Gulf Oil International	c/o IN Centre, 49/50, MIDC 12th Road, Marol, Andheri (East) Mumbai - 400093 India	31-Oct-15	PRI GL 0450	Gulf Gear ST 80W-90	SAE 80W-90
Gulf Oil International	c/o IN Centre, 49/50, MIDC 12th Road, Marol, Andheri (East) Mumbai - 400093 India	31-Oct-15	PRI GL 0451	Gulf Gear DB Dura Max 85W-140	SAE 85W-140
Hi-Tec Oil Traders Pty Ltd.	5 Tarlington Place Smithfield, New South Wales 2164 Australia	30-Sep-18	PRI GL 0663	Hi-Tec Syngear 75W-90 V Extra	SAE 75W-90
Hicks Oils & Hicksgas, Inc.	845 North Hickory Street DuQuoin, Illinois 62832 USA	30-Apr-16	PRI GL 0605	Venom Synthetic	SAE 75W-90
Hindustan Petroleum Corporation Ltd.	8, Soorjee Vallabhdas Marg Ballarad Estate, Mumbai - 400001 Maharashtra (India)	31-Jul-15	PRI GL 0594	HP Gear Oil XXP 80W-90	SAE 80W-90
Hindustan Petroleum Corporation Ltd.	8, Soorjee Vallabhdas Marg Ballarad Estate, Mumbai - 400001 Maharashtra (India)	31-Jul-15	PRI GL 0595	HP Gear Oil XXP 85W-140	SAE 85W-140
Indian Oil Corporation Ltd.	Indian Oil Bhavan, G-9 Ali Yavar Jung Marg, Bandra (East) Mumbai - 400051	31-Jul-15	PRI GL 0509	SERVO GEAR AXLE 85W-140	SAE 85W-140
Ipiranga Produtos de Petroleo S.A.	Rua Monsenhor Manoel Gomes, 140 Sao Cristovao, Rio de Janerio - RJ Brazil 20931-670	31-Oct-16	PRI GL 0633	Ipiranga Ultragear Premium 75W90	SAE 75W-90
Kuwait Petroleum Research & Technology B.V.	Moezelweg 251 3198 LS Europoort Rt, The Netherlands	31-May-17	PRI GL 0510	Q8 Gear Oil XG, SAE 80W-90	SAE 80W-90
Kuwait Petroleum Research & Technology B.V.	Moezelweg 251 3198 LS Europoort Rt, The Netherlands	30-Sep-18	PRI GL 0627	Q8 Trans XGS 75W-90	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0417	OS 258716	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0418	OS 258717	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0419	OS 259596	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0420	OS 257906	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0421	OS 257202	SAE 75W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0422	OS 259011	SAE 80W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0425	OS 253104A	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-15	PRI GL 0426	OS 253105	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-15	PRI GL 0435	OS 260611	SAE 80W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-15	PRI GL 0436	OS 260902	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-15	PRI GL 0437	OS 236254	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-15	PRI GL 0438	OS 216983	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-15	PRI GL 0454	OS 267146	SAE 75W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-15	PRI GL 0455	OS 267505	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-15	PRI GL 0456	OS 267506	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Jun-16	PRI GL 0470	OS 266136	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Jun-16	PRI GL 0471	OS 272873	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Jun-16	PRI GL 0472	OS 272872	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Oct-16	PRI GL 0486	OS 275887	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Oct-16	PRI GL 0487	OS 274532	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Oct-16	PRI GL 0490	Anglamol®2005	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-16	PRI GL 0493	OS 275585	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-16	PRI GL 0494	OS 273972A	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-16	PRI GL 0495	OS 280927	SAE 75W-110
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-17	PRI GL 0500	OS 285973	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-17	PRI GL 0501	OS 284758	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-17	PRI GL 0502	OS 285323	SAE 75W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-17	PRI GL 0519	OS 287043	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-17	PRI GL 0520	OS 287044	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jan-18	PRI GL 0547	OS 294115	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jan-18	PRI GL 0548	OS 273000	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-18	PRI GL 0556	OS 299018	SAE 80W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-18	PRI GL 0557	OS 299019	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-18	PRI GL 0558	OS 299020	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-18	PRI GL 0559	OS 299021	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Apr-18	PRI GL 0560	OS 300588	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Apr-18	PRI GL 0561	OS 295765	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-18	PRI GL 0588	OS 303885	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-18	PRI GL 0589	OS 303886	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-18	PRI GL 0590	OS 303887	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-18	PRI GL 0591	OS 303888	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-18	PRI GL 0592	OS 306752	SAE 75W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-18	PRI GL 0600	OS 305326	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-18	PRI GL 0601	OS 305327	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-18	PRI GL 0602	Anglamol® 6055	SAE 75W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-18	PRI GL 0606	OS311112	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Sep-18	PRI GL 0607	OS308725B	SAE 75W-85
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-18	PRI GL 0621	OS 277186B	SAE 75W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-18	PRI GL 0622	OS 277605H	SAE 75W-85
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-18	PRI GL 0623	OS 312630	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Dec-18	PRI GL 0624	OS 312631	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	28-Feb-19	PRI GL 0629	OS 308826	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	28-Feb-19	PRI GL 0630	OS 308827	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-19	PRI GL 0646	OS 322784	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-19	PRI GL 0647	OS 322785	SAE 85W-140

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-19	PRI GL 0650	OS 323893	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Jul-19	PRI GL 0651	OS 323894	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Oct-19	PRI GL 0675	OS 278624V	SAE 75W-85
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Nov-19	PRI GL 0678	OS 331070	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	28-Feb-20	PRI GL 0700	OS 331340A	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	28-Feb-20	PRI GL 0701	OS 336576A	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	28-Feb-20	PRI GL 0702	OS 333757A	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-20	PRI GL 0716	OS 336583A	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-20	PRI GL 0717	OS 336584A	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-20	PRI GL 0718	OS 336585A	SAE 80W-90
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	31-Mar-20	PRI GL 0719	OS 336586A	SAE 85W-140
Lubrizol Corporation, The	29400 Lakeland Boulevard Wickliffe, Ohio 44092 USA	30-Apr-20	PRI GL 0722	OS 253828A	SAE 75W-140
Meguin GmbH & Co., KG	Rodener Strasse 25 66740 Saariouis Germany	30-Sep-18	PRI GL 0659	megol Getriebeoel Truck-Synth, SAE 75W-90	SAE 75W-90
Opet Fuchs Madeni Yag Sanayi ve Ticaret S.A.	Kisikli Mah. Alemdag Cad. Masaldan Is Merkezi. C Blok No:60 Kat:2 Uskudar 34696 Istanbul, Turkey	30-Jun-17	PRI GL 0555	FULLGEAR HYP PLUS 85W-140	SAE 85W-140
PT. PERTAMINA (PERSERO)	Lubricants Business Unit Oil Center 6th Jalan MH, Thamrin Kav. 55 Jakarta	31-Mar-17	PRI GL 0571	Rored HD-A XT 85W-140	SAE 85W-140
Pakelo Motor Oil S.r.l.	Via Fontanelle 52/54 37047 San Bonifacio Verona, Italy	30-Sep-18	PRI GL 0619	Global Multigear TS SAE 75W/90	SAE 75W-90
Pakelo Motor Oil S.r.l.	Via Fontanelle 52/54 37047 San Bonifacio Verona, Italy	31-Dec-18	PRI GL 0641	ArM Gear Lube 5 SAE 75W-85	SAE 75W-85
Petro-Canada Lubricants Inc.	2489 North Sheridan Way Mississauga, Ontario L5K 1A8 Canada	30-Sep-15	PRI GL 0433	TRAXON 80W-90	SAE 80W-90
Petro-Canada Lubricants Inc.	2489 North Sheridan Way Mississauga, Ontario L5K 1A8 Canada	30-Sep-15	PRI GL 0434	TRAXON 85W-140	SAE 85W-140
Petro-Canada Lubricants Inc.	2489 North Sheridan Way Mississauga, Ontario L5K 1A8 Canada	31-Dec-15	PRI GL 0457	TRAXON XL S.B. 75W-90	SAE 75W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Petronas Lubricants Italy S.P.A.	Via Santena 1 10029 Villastellone (TO) Italy	30-Sep-18	PRI GL 0631	Tutela Transmission Stargear AX-ED	SAE 75W-90
Petronas Lubricants Italy S.P.A.	Via Santena 1 10029 Villastellone (TO) Italy	31-Jul-18	PRI GL 0632	Tutela Transmission X-Road	SAE 75W-90
Petronas Lubrificantes Brasil S.A.	Avenida Trajano de Araujo Viana 2500 Contagem - MG Brasil	30-Nov-19	PRI GL 0703	Tutela TRD 85W-140	SAE 85W-140
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	1000 South Pine Street 4570 RW Ponca City, Oklahoma 74602 USA	30-Sep-15	PRI GL 0463	Kendall NS-MP Hypoid Gear Lubricant, SAE 85W-140	SAE 85W-140
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	1000 South Pine Street 4570 RW Ponca City, Oklahoma 74602 USA	30-Jun-15	PRI GL 0464	76 MP Gear Lube, SAE 80W-90	SAE 80W-90
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	1000 South Pine Street 4570 RW Ponca City, Oklahoma 74602 USA	30-Jun-15	PRI GL 0465	76 MP Gear Lube, SAE 85W-140	SAE 85W-140
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	1000 South Pine Street 4570 RW Ponca City, Oklahoma 74602 USA	30-Sep-15	PRI GL 0466	Kendall NS-MP Hypoid Gear Lubricant, SAE 80W-90	SAE 80W-90
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	30-Apr-16	PRI GL 0615	Kendall Super Three Star® Synthetic Gear Lubricant	SAE 75W-90
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	30-Apr-16	PRI GL 0616	Kendall Super Three Star® Synthetic Gear Lubricant	SAE 80W-140
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0679	76 MP Gear Lube	SAE 80W-90
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0680	76 MP Gear Lube	SAE 85W-140
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0681	Conoco Universal Gear Lubricant	SAE 80W-90
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0682	Conoco Universal Gear Lubricant	SAE 85W-140
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0683	Kendall NS-MP Hypoid Gear Lubricant	SAE 80W-90
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0684	Kendall NS-MP Hypoid Gear Lubricant	SAE 85W-140

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0685	Phillips 66 SMP Gear Oil, SAE 80W-90	SAE 80W-90
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Oct-19	PRI GL 0686	Phillips 66 SMP Gear Oil, SAE 85W-140	SAE 85W-140
Phillips 66 (previously known as ConocoPhillips prior to May 1, 2012)	Phillips 66 Research Center Highways 60 & 123, Building 101-G Bartlesville, Oklahoma 74003-6670	31-Mar-20	PRI GL 0721	76 MP Gear Lube	SAE 80W-90
Raloy Lubricantes, S.A. de C.V.	Av. Del Convento No.111 Parque Industrial Santiago Tianguistenco C.P. 52600, Mexico	31-Mar-16	PRI GL 0467	Diferenciales 85W-140 GL-5 (MT-1/SAE J2360)	SAE 85W-140
Raloy Lubricantes, S.A. de C.V.	Av. Del Convento No.111 Parque Industrial Santiago Tianguistenco C.P. 52600, Mexico	30-Jun-19	PRI GL 0706	Transmisión SAE 80W-90 GL-5 MB	SAE 80W-90
Safety-Kleen	Lubricants Division 300 Woolwich Street South Breslau, Ontario Canada N0B 1M0	30-Jun-15	PRI GL 0460	America's Choice 2105 Gear Oil	SAE 80W-90
Safety-Kleen	Lubricants Division 300 Woolwich Street South Breslau, Ontario Canada N0B 1M0	30-Jun-15	PRI GL 0461	America's Choice 2105 Gear Oil	SAE 85W-140
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	31-Mar-17	PRI GL 0515	Shell SPIRAX S SAE 75W-140	SAE 75W-140
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	31-Aug-17	PRI GL 0525	OLD NAME: Shell SPIRAX HD 80W-90 NEW NAME: Spirax S4 AX 80W-90	SAE 80W-90
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	31-Aug-17	PRI GL 0526	OLD NAME: Shell SPIRAX HD 85W-140 NEW NAME: Spirax S4 AX 85W-140	SAE 85W-140
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	31-Mar-18	PRI GL 0584	OLD NAME: SPIRAX HD SAE 80W-90 NEW NAME: Spirax S4 AX 80W-90	SAE 80W-90
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	31-Mar-18	PRI GL 0585	OLD NAME: SPIRAX HD SAE 85W-140 NEW NAME: Spirax S4 AX 85W-140	SAE 85W-140
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	31-Jan-19	PRI GL 0625	OLD NAME: Shell Spirax HD SAE 80W-90 NEW NAME: Spirax S4 AX 80W-90	SAE 80W-90
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	31-Jan-19	PRI GL 0626	OLD NAME: Shell Spirax HD SAE 85W-140 NEW NAME: Spirax S4 AX 85W-140	SAE 85W-140
Shell International Petroleum Company, Ltd.	Shell Centre, London SE1 7NA, United Kingdom	30-Jun-18	PRI GL 0582a	Shell SPIRAX S6 AXME	SAE 75W-90
Shell International Petroleum Company, Ltd.	3333 Highway 6 South Houston, Texas 77082-3101 USA	30-Nov-19	PRI GL 0677	Sprax S4 AX 85W-140	SAE 85W-140
Sinopec Lubricant Co., Ltd.	No. 6 Anning Zhuang West Road Haidian District Beijing, P.R. China 100085	30-Jun-17	PRI GL 0521	Ultra Automotive Gear Oil	SAE 80W-90
Total Lubrifiants SA	MKA/DPA-LE Spazio 562 Avenue du parc de l'Ile 92029 Nanterre Cedex France	30-Jun-16	PRI GL 0660	TOTAL Transmission XPM 80W-90	SAE 80W-90

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Company Name	Address	Expiration Date	PRI QPL #	Brand Name	SAE Viscosity Grade
Total Lubrifiants SA	MKA/DPA-LE Spazio 562 Avenue du parc de l'Ile 92029 Nanterre Cedex France	30-Sep-18	PRI GL 0661	TOTAL Transmission Syn FE 75W-90	SAE 75W-90
Total Lubrifiants SA	MKA/DPA-LE Spazio 562 Avenue du parc de l'Ile 92029 Nanterre Cedex France	31-Dec-16	PRI GL 0662	TOTAL Transmission XPM 80W-90	SAE 80W-90
Total Specialties USA, Inc. dba Total Lubricants USA, Inc.	5 North Stiles Street Linden, New Jersey 07036 USA	31-Jul-15	PRI GL 0569	Transmission XML 85W-140	SAE 85W-140
Total Specialties USA, Inc. dba Total Lubricants USA, Inc.	5 North Stiles Street Linden, New Jersey 07036 USA	31-Aug-17	PRI GL 0570	Transmission XML 80W-90	SAE 80W-90
U.S. Venture, Inc.	425 Better Way Appleton, Wisconsin 54915 USA	30-Jun-18	PRI GL 0586	Wide Range Gear Oil 85W-140	SAE 85W-140
U.S. Venture, Inc.	425 Better Way Appleton, Wisconsin 54915 USA	30-Jun-18	PRI GL 0587	Wide Range Gear Oil 80W-90	SAE 80W-90
Valvoline Company, The	3499 Blazer Parkway Lexington, Kentucky 40512-1400 USA	30-Sep-15	PRI GL 0452	Valvoline SynGard™ FE Gear Oil	SAE 75W-90

APPENDIX B.

Technical Data sheets for Commercially Available Fuel Efficiency Gear Oils

Drive Axle Lubricant Data Sheet

Roadranger® Synthetic Gear Lubricants are API GL-5 extreme pressure lubricants designed to promote longer gear life and better operating economy thus improving fuel economy in heavy, mid and light-duty applications. They are formulated using synthetic base stock, which has a high viscosity index and an exceptionally low pour point.

Roadranger Synthetic Gear Lubricants Outperform Conventional Gear Lubricants

- Longer Axle Component Life
  - Reduces Gear Wear
  - Less Frequent Maintenance
  - Less Oil Disposal
  - Increases Vehicle Uptime
- Improves Protection In Extreme Conditions
  - Severe Low and High Temperature properties
- Extended Drain and Extended Warranty Protection
- Genuine OEM Equipment

NEW Roadranger FE 75W-90 Fuel Efficient Synthetic Gear Lubricant Benefits:

- Better operating performance – superior lubricating properties and a lower viscosity profile may improve fuel mileage.
- Meets the latest DANA Specification SHAES 256 Rev C
- Fuel Economy
  - Fuel Efficient – Quantifiable Fuel Savings
  - 1% Plus Improvement – Industry and Fleet Testing Methods

Roadranger 75W-90 Synthetic Gear Lubricant:

- For over 15 years, Roadranger 75W-90 Synthetic Gear Lubricant has remained the industry standard in extended drain heavy-duty commercial vehicle gear lubricants.
- Approved by all major axle and truck manufacturers.
- Meets the latest DANA Specification SHAES 256 Rev C
- Extended Drain and Extended Warranty Protection
- Genuine OEM Equipment

Roadranger 80W-140 Synthetic Gear Lubricant:

- Roadranger 80W-140 Synthetic Gear Lubricants is used in Off-Road vehicles or where high viscosity lubricants are required.
- Genuine OEM Equipment

Synthetic Gear Lubricants

Typical Characteristics

	ROADRANGER® FE 75W-90 FUEL EFFICIENT SYNTHETIC GEAR LUBRICANT	ROADRANGER 75W-90 SYNTHETIC GEAR LUBRICANT	ROADRANGER 80W-140 SYNTHETIC GEAR LUBRICANT	TEST METHODS
Part #	2986	2984	2831	
Appearance, visual	Amber	Amber	Amber	
SAE Grade	75W-90	75W-90	80W-140	SAE J-300
Viscosity, cSt				ASTM D-445
100°C	15.0	16.6	30.6	
40°C	103	122	284	
Viscosity, SUS				ASTM D-2161
210°F	72	86	149	
100°F	620	626	1470	
Viscosity, cP -26°C	–	–	75,000	ASTM D-2983
-40°C	90,000	125,000	–	
Viscosity index	152	147	146	ASTM D-2270
Pour point, °C (°F)	<-45 (<-48)	<-45 (<-48)	<-40 (<-40)	ASTM D-97
Flash point, °C (°F)	215 (420)	204 (400)	200 (395)	ASTM D-92
Foam				ASTM D-892
sequence I	pass	pass	pass	
sequence II	pass	pass	pass	
sequence III	pass	pass	pass	
API gravity 15.6/15.6°C	27.3	25.2	23.6	ASTM D-287
Density, g/l, 15.6°C	891	891	902	
(lbs./gal., 60°F)	(7.42)	(7.42)	(7.51)	ASTM D-1298
Copper strip corrosion				ASTM D-130
3 hrs. at 100°C (212°F)	1a	1a	1a	
3 hrs. at 121°C (250°F)	1a	1a	1a	

OEM Approvals/Specifications

API	GL-5, MT-1	GL-5, MT-1	GL-5, MT-1
MIL	MIL-PRF-2105E	MIL-PRF-2105E	MIL-PRF-2105E
SAE	SAE J 2360	SAE J 2360	SAE J 2360
ArvinMeritor	O76-N, O76-E	O76-N, O76-E	O76-N, O76-E
DANA	SHAES-256 Rev C	SHAES-256 Rev C	SHAES-429 Rev A
International	TMS 6816	TMS 6816	TMS 6816
Mack	GO-J Plus	GO-J Plus	

Suggestions for the use and application of our products and guide formulations are given to the best of our knowledge and information and without obligation. Such suggestions do not release our customers from testing our products for themselves as to their suitability for the intended processes and purposes. If, however, we should be liable for damage, our liability shall be limited to damages resulting from wilful acts or gross negligence. In no event shall we be liable for indirect damages. Every user of our products is responsible regarding observation of legal regulations including patent rights.

NOTE: Material Safety Data Sheets for these products are provided with samples or are provided on request. Users of these products are urged to study and use this information.

Roadranger®

DANA | EATON

For spec'ing or service assistance, call 1-800-826-HELP (4357) 24 hours a day, 7 days a week (Mexico: 001-800-826-4357), for more time on the road. Or visit our web site at www.roadranger.com.

Roadranger: Eaton, Dana and other trusted partners providing the best products and services in the industry, ensuring more time on the road.

® = registered trademark of BASF SE

Emgard® FE 75W-90 Fuel Efficient Synthetic Gear Lubricant

General characterization

Emgard FE 75W-90 synthetic gear lubricant is an API GL-5 extreme pressure gear lubricant for improved fuel economy in heavy, mid and light duty applications compared to typical petroleum 80W-90 or synthetic 75W-90 gear lubricants. It is formulated using synthetic basestocks, which have a high viscosity index and an exceptionally low pour point. This lubricant contains extreme pressure additives, as well as rust, oxidation and corrosion inhibitors to protect gears and bearings operated under a wide variety of load conditions. The fluid also has an optimized viscosity to allow lower churning losses and still maintain adequate bearing and gear protection. The high and low temperature performance of this product exceeds those of conventional SAE 90, 75W-90 and 80W-90 hypoid gear lubricants.

Approvals:
- API Service Classifications, GL-5 and MT-1
- MIL-PRF-2105E/SAE 2360
- ArvinMeritor, 076-N
- Dana Corporation, SHAES 256 Rev C & 429
- International Truck, TMS 6816
- Mack Truck, GO-J Plus

Additional product descriptive data

Emgard FE 75W-90 synthetic gear lubricant outperforms conventional gear lubricants to promote longer gear life and better operating economy. Some of the major advantages are:

- Better operating performance – As a result of the superior lubricating properties and low viscosity profile of the Emgard FE 75W-90, improved fuel mileage can be realized.
- Increased gear life – These extreme pressure (EP) lubricants result in longer gear life by providing extremely high film strength and superior low temperature performance. They also have anti-rust and anti-corrosion properties to further promote extended gear and bearing life.
- Extended drain, all-season lubrication – With an extremely low channel point and high viscosity index, this lubricant provides excellent performance over a broad temperature range. Furthermore, Emgard FE 75W-90 resists oxidation; it will last significantly longer than conventional gear oils.

- Reduced maintenance and downtime – All of the foregoing advantages of this lubricant translate directly into reduced maintenance and less downtime.

Performance data

Low temperature viscosity comparison of Emgard FE 75W-90, 75W-90 and Petroleum 80W-90:

Properties	Emgard FE 75W-90	Emgard 75W-90	Petroleum-based 80W-90
Brookfield viscosity, cP			
0 °F (– 18 °C)	5,850	7,125	18,350
– 20 °F (– 29 °C)	20,750	24,500	139,500
– 40 °F (– 40 °C)	90,000	125,000	2,000,000
Kinematic viscosity, cSt.			
210 °F (99 °C)	15.1	16.7	14.4
250 °F (121 °C)	9.7	9.9	8.9

Typical characteristics

Properties	Emgard FE 75W-90	Test method
SAE grade	75W-90	J-306
Viscosity, cSt		ASTM D-445
100 ºC	15.0	ASTM D-445
40 ºC	103	ASTM D-445
Viscosity index	152	ASTM D-2270
Viscosity, SUS		ASTM D-2161
210 ºC	72	ASTM D-2161
100 ºC	620	ASTM D-2161
Viscosity, cP		ASTM D-2983
– 1B °C (0 °F)	5,850	ASTM D-2983
– 29 °C (– 20 °F)	20,750	ASTM D-2983
– 40 °C (– 40 °F)	90,000	ASTM D-2983
Flash point, ºC (ºF)	215 (420)	ASTM D-92
Channel point, °C	< – 45	FTMS-3456
Density, g/l, 15.6 °C (lbs/gal, 60 °F)	891 (7.39)	ASTM D-1298
Foam test		ASTM D-892
Sequence I	pass	ASTM D-892
Sequence II	pass	ASTM D-892
Sequence III	pass	ASTM D-892
Copper strip corrosion		ASTM D-130
3 hrs, at 100 °C (212 °F)	1a pass	ASTM D-130
3 hrs, at 121 °C (250 °F)	1a pass	ASTM D-130
FZG, load stage, pass	12	ASTM D-5182

* *BASF Product Code: 2986*

** *BASF Synlubes technology is certified under IS0 9001 and IS0 TS 16949*

Application

Use	Emgard FE 75W-90 synthetic gear lubricant is recommended for applications where heat and wear present major problems. These applications include manual transmissions where EP type lubricants are recommended, differentials including limited slip, and transfer cases for heavy equipment, trucks, tractors and industrial gear drives. Automobiles, light duty trucks and farm machinery are other potential uses of this lubricant.
Technical Application Data	**Performance benefits of Emgard FE 75W-90 over conventional gear lubricants** – fuel efficient, quantifiable fuel savings – 1% plus improvement, Industry and fleet testing methods – longer axle component life – reduced gear wear – less frequent maintenance, less oil disposal – increased vehicle uptime – longer component life – improved protection in extreme conditions – severe low and high temperature properties – extended drain and extended warranty protection – genuine OEM equipment

Transportation, handling & storage

Handling	Please refer to material safety data sheet for details.
Shelf life	Subject to appropriate storage in closed original containers under the usual storage and temperature conditions, Emgard FE 75W-90 is stable for at least 3 years.

Note

The data contained in this publication are based on our current knowledge and experience. In view of the many factors that may affect processing and application of our product, these data do not relieve processors from carrying out their own investigations and tests; neither do these data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose. Any descriptions, drawings, photographs, data, pro- portions, weights etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed.

We support worldwide Responsible Care® initiatives. We value the health and safety of our employees, customers, suppliers and neighbors, and the protection of the environment. Our commitment to Responsible Care is integral to conducting our business and operating our facilities in a safe and environmentally responsible fashion, supporting our customers and suppliers in ensuring the safe and environmentally sound handling of our products, and minimizing the impact of our operations on society and the environment during

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production, storage, transport, use and disposal of our products.

October 2012

FLEETRITE®

FLEETRITE®

THE RITE PARTS, RIGHT NOW.

NAVISTAR®

RITE
FROM THE START.

For more than 40 years, Fleetrite has provided quality parts for all vehicle makes and models to customers at competitive prices. Our parts are sold at more than 700 International Truck and IC Bus dealer locations nationwide. Every part is Navistar aftermarket quality approved, and is covered by a one-year parts and labor warranty.

THE RESULT: You get everything RITE the first time.

- AUTOMATIC TRANSMISSION FLUID
- DIESEL EXHAUST FLUID
- GENUINE FACTORY-FILL FULL SYNTHETIC LUBRICANTS
- RE-REFINED OIL
- COOLANT

FLEETRITE®

AUTOMATIC TRANSMISSION FLUID

QUALITY ALL-MAKES PARTS YOU CAN DEPEND ON

Navistar is excited to offer Fleetrite® synthetic automatic transmission fluid (ATF), a premium synthetic universal powershift and automatic transmission fluid that is TES-295 approved for use in Allison transmissions. Fleetrite synthetic ATF is approved for Allison's Extended Transmission Coverage Programs.

KEY FEATURES AND BENEFITS

- Excellent thermal oxidation stability that resists deposit formation
- High viscosity index synthetic-base fluids, which provide superior high/low temperature performance
- Excellent shear stability, corrosion and foaming resistance
- Reduces used oil disposal costs
- Extends drain and filter change intervals
- Compatibility with most other automotive transmission fluids and seals
- One fluid for year-round use in all geographic locations
- Reduces start-up wear
- Extends drain and filter change intervals in Allison TES-295 approved equipment

Fleetrite® Synthetic Automatic Transmission Fluid meets or exceeds the following listed or approved OEM specifications:

- Allison TES-295 (AN-031004)
- Allison TES 468
- Allison C4 (33004203)
- ZF TE-ML 14C
- Voith H55.633636
- DEXRON®-III G (G-34746)

Fleetrite Part Number	Contents
SYNTHETIC AUTOMATIC TRANSMISSION FLUID	
FLTATF295Q	32-Ounce Quart (0.946 L)
FLTATF295G	1 Gallon Bottle (3.785 L)
FLTATF295P	5-Gallon Pail (18.93 L)
FLTATF295D	55-Gallon Drum (208.17 L)

DIESEL EXHAUST FLUID

YOUR INTERNATIONAL DEALER IS NOW YOUR ONE-STOP SHOP

Diesel exhaust fluid (DEF) is quickly becoming the second most consumed liquid in trucks with selective catalytic reduction (SCR) technology, and now you can get the fluid at your local International dealer. Fleetrite® diesel exhaust fluid is tested to original equipment manufacturer (OEM) specifications and is American Petroleum Institute (API) certified. Plus, you can trust the private-label Fleetrite brand — established more than 40 years ago and known for its superior value and quality.

FLEETRITE DIESEL EXHAUST FLUID SIZING AND STORAGE

- Six package sizes available:
  - 2.5-gallon bottle with nozzle
  - 55-gallon drum
  - 275-gallon tote
  - 330-gallon tote
  - Tote fills
  - Bulk: 700–2,000 gallons, 2,001–4,800 gallons, 4,801+ gallons
- Properly stored, DEF can last up to 36 months. We offer equipment and accessories to provide a complete storage solution.

FLEETRITE DIESEL EXHAUST FLUID FACTS

- DEF is nonhazardous, consisting of 67.5% deionized water and 32.5% urea.
- One gallon = 300–400 miles in range.
- DEF weighs 9.1 pounds per gallon.
- Fleetrite DEF meets ISO 22241 and is API certified.
- DEF is a nontoxic, nonpolluting and nonflammable substance.
- DEF and SCR, according to engine manufacturers, improve overall fuel economy by approximately 5% compared to competing technologies and achieve NOx reductions in excess of 90%.
- If DEF freezes, it can be thawed and used, and it will not be damaged or destroyed if frozen.
- DEF consumption is expected to be approximately 2%–3% of the diesel fuel consumed, depending on application and vehicle operation.

RECOMMENDED STORAGE MATRIX

SCR Vehicles		DEF Usage Per Period**				
# Veh	Diesel Gal/Wk*	Week	Month	Quarter	Year	Storage
1+	500	10	40	160	640	55-Gal Drum
3+	1,000	20	80	320	1,280	
5+	2,000	40	160	640	2,560	
8+	3,000	60	240	960	3,840	275-Gal Tote
10+	4,000	80	320	1,280	5,120	
13+	5,000	100	400	1,600	6,400	
26+	10,000	200	800	3,200	12,800	1–2K-Gal Tank
40+	15,000	300	1,200	4,800	19,200	
50+	20,000	400	1,600	6,400	25,600	3–4K-Gal Tank
80+	30,000	600	2,400	9,600	38,400	
160+	60,000+	1,200	4,800	19,200	76,800	Tank

Assumptions: *120,000 miles per year, 6 mpg
**2% DEF per gallon of diesel

PRODUCT SPECIFICATIONS

Fleetrite Part Number	Description
FLTFP	Fleetrite Diesel Exhaust Fluid — 2.5-Gallon Bottle (9.46 L)
FLTFQ	Fleetrite Diesel Exhaust Fluid — 55-Gallon Drum (208.2 L)
FLTFR	Fleetrite Diesel Exhaust Fluid — 275-Gallon Tote (1041 L)
FLTFS	Fleetrite Diesel Exhaust Fluid — 330-Gallon Tote (1249.2 L)
FLTFB	Fleetrite Diesel Exhaust Fluid — Bulk Delivery

API AMERICAN PETROLEUM INSTITUTE CERTIFIED DIESEL EXHAUST FLUID

For more information and to find a dealer near you, visit www.fleetrite.com

GENUINE FACTORY-FILL FULL SYNTHETIC LUBRICANTS

QUALITY ALL-MAKES PARTS YOU CAN DEPEND ON

Fleetrite® full synthetic lubricants from Navistar help reduce operating costs and extend vehicle warranties. All lubricants resist heat and oxidation much longer than standard petroleum gear oils.

Fleetrite full synthetic lubricants provide the maximum drain interval to safeguard component warranties, and are approved for 500,000-mile drain intervals in OEM on-highway 750,000-mile extended warranty programs.

KEY FEATURES AND BENEFITS

- Lower life-cycle cost
- Increased fuel economy
- Longer component life
- Longer drains
- Resists heat and oxidation much longer than petroleum gear oils
- Noncorrosive to copper and other yellow metal parts within heavy-duty components
- OEM warranty approvals

SAE 75W-90 AND FE 75W-90 FULL SYNTHETIC GEAR LUBRICANT COMPONENT APPROVALS:

- API GL-5, API MT-1
- MIL-PRF-2105E/SAE J2360
- Meritor O76-N
- Dana SHAES-256 Rev C, SHAES-429
- International TMS 6816
- Mack GO-J plus

SAE 80W-140 FULL SYNTHETIC GEAR LUBRICANT COMPONENT APPROVALS:

- API GL-5, API MT-1
- MIL-PRF-2105E/SAE J2360
- Dana SHAES-429
- Meritor O80, O76-B
- International TMS 6816
- Mack GO-J

Roadranger® Genuine Lubricants EATON®

SUPPORTED BY YOUR ROADRANGER® TEAM

SAE 50 FULL SYNTHETIC MANUAL TRANSMISSION LUBRICANT COMPONENT APPROVALS:

- API MT-1
- Eaton PS-164 Rev 7
- Mack TO-A Plus, Mack mDRIVE
- International TMS 6816
- ZF-FreedomLine (ZF-AS Tronic)
- Meritor O81
- Volvo 97305, Volvo I-Shift (75,000 miles)

Fleetrite Part Number	Contents
SAE 75W-90 FULL SYNTHETIC GEAR LUBRICANT	
FLTW75W90G	1 Gallon Bottle (3.785 L)
FLTW75W90P	5-Gallon Pail (18.93 L)
FLTW75W90D	55-Gallon Drum (208.17 L)
SAE 80W-140 FULL SYNTHETIC GEAR LUBRICANT	
FLTW80W140G	1 Gallon Bottle (3.785 L)
FLTW80W140P	5-Gallon Pail (18.93 L)
FLTW80W140D	55-Gallon Drum (208.17 L)
SAE 50 FULL SYNTHETIC MANUAL TRANSMISSION LUBRICANT	
FLTSAE50G	1 Gallon Bottle (3.785 L)
FLTSAE50P	5-Gallon Pail (18.93 L)
FLTSAE50D	52-Gallon Drum (196.84 L)

FE 75W-90 TAKES YOU FURTHER:

FE 75W-90 Fuel Efficient and Full Synthetic Gear Oil/Axle Lubricant

- Quantifiable fuel savings 1% plus improvement — industry and fleet testing methods
- Better operating performance
- Reduced maintenance and downtime

Fleetrite Part Number	Contents
FE 75W-90 FUEL EFFICIENT AND FULL SYNTHETIC AXLE LUBRICANT	
FLTFE75W90G	1 Gallon Bottle (3.785 L)
FLTFE75W90P	5-Gallon Pail (18.93 L)
FLTFE75W90D	55-Gallon Drum (208.17 L)

NAVISTAR®

RE-REFINED OIL

QUALITY ALL-MAKES PARTS YOU CAN DEPEND ON

Navistar is excited to provide a high-quality synthetic blend of Fleetrite® re-refined engine oil, designed to extend oil drains and deliver superior results under the toughest operating conditions. Fleetrite re-refined engine oil meets or exceeds the same standards as virgin oil and is Navistar aftermarket quality approved.

PRODUCT HIGHLIGHTS

- Fleetrite re-refined oil is American Petroleum Institute (API) certified.
- Fleetrite re-refined engine oil products are blended with premium additives for high performance and designed to keep engines free of harmful deposits, varnishes and resins.
- Tested to OEM specifications
- Aids in achieving corporate sustainability goals and helps protect the environment
- Made in the U.S.A.
- Four package sizes are available through the Fleetrite Re-Refined Engine Oil Program.
  - 1 gallon bottle (3/1 per case)
  - 5-gallon pail
  - 55-gallon drum
  - Bulk (220-gallon minimum)
  - Bulk tank purchased separately

Fleetrite Part Number	Contents
FLTRR15W40G	Fleetrite SAE 15W-40 HD CJ4 1 Gallon Bottle (3.785 L)
FLTRR15W40P	Fleetrite SAE 15W-40 HD CJ4 5-Gallon Pail (18.93 L)
FLTRR15W40D	Fleetrite SAE 15W-40 HD CJ4 55-Gallon Drum (208.17 L)
FLTRR15W40B	Fleetrite SAE 15W-40 HD CJ4 Bulk Delivery

PREMIUM FLEETRITE RE-REFINED ENGINE OIL FACTS

- Provides outstanding engine protection in accordance with EPA emissions standards for on-highway diesel trucks using ultralow-sulfur diesel (ULSD) or off-highway applications using low-sulfur diesel (LSD).
- Re-refining motor oil requires up to 89% less energy to produce and reduces harmful emissions by up to 65% compared to refining foreign crude oil.
- Executive Order 13149 “Greening the Government Through Federal Fleet and Transportation Efficiency” mandates federal agencies to use re-refined oils where available.
- One average 12-gallon diesel engine oil change using Fleetrite re-refined engine oil can reduce foreign oil dependency by approximately 18 barrels of crude oil.
- Additive package technology proven in more than 2.5 trillion miles of operation.

Meets or exceeds the following tests and requirements:

- API Service Classification – CJ-4, CI-4 Plus, CI-4, CH-4, CG-4, CF, SM(15W-40), SL
- Caterpillar – ECF-1, ECF-3, C-13
- Mack – EO-O Prem Plus ’07 (15W-40), EO-N Prem Plus ’03
- Detroit Diesel – 93K214, 93K215, 93K217, 93K218 (15W-40)
- Cummins – CES 20081
- Navistar – HEUI Foam
- GM – 6.5L (RFWT)
- Volvo – VDS-2, VDS-3, VDS-4 (15W-40)
- Global – DHD-1
- JASO – DH-1
- Daimler Chrysler – P228.3
- ACEA – E7-04, E2, E4
- John Deere – Plus-50

MADE IN USA

API SERVICE CJ-4, CI-4 PLUS, CH-4, CF/SL SAE 15W-40

For more information and to find a dealer near you, visit www.fleetrite.com

NOAT AND NITRITE-FREE EXTENDED LIFE COOLANTS

QUALITY ALL-MAKES PARTS YOU CAN DEPEND ON

Fleetrite® NOAT and nitrite-free extended life coolants are formulated for all heavy-duty diesel, gasoline and natural gas engine cooling systems.

All Fleetrite NOAT coolants are designed to prevent long-term wet sleeve liner cavitation and provide corrosion protection and outstanding heat transfer, while nitrite-free coolants use organic acid inhibitors to provide guaranteed protection for all cooling system metals.

PRODUCT HIGHLIGHTS

- Works in ALL heavy-duty diesel, gasoline and natural gas engine cooling systems
- NOAT Extended Life guaranteed protection for 750,000 MILES of on-road use (8 years or 15,000 hours of off-road use)*
- Nitrite-free guaranteed protection for ONE MILLION MILES of on-road use (8 years or 20,000 hours of off-road use)*
- Eliminates the need for SCAs and chemically charged filters
- Excellent heat transfer for high-temperature applications, such as engines with EGR and SCR systems
- Outstanding protection against corrosion and cavitation
- Nonabrasive formula can improve water pump seal life
- Eliminates drop-out and gel, and reduces scale
- Can be mixed with other coolants, (to maintain corrosion protection, contamination levels should be kept below 25%)
- Provides exceptional long-term elastomer compatibility

NOAT Extended Life	Meets or exceeds the following specifications:
ASTM D6210 ASTM D4340	ASTM D3306 TMC RP329 TMC RP351 (COLOR)
Recommended for use in heavy-duty vehicles and stationary equipment, regardless of fuel type, including:	
Caterpillar EC-1 Cummins CES 14603 John Deere H24A1, H24C1 Navistar PACCAR Volvo/Mack JL Case	Komatsu International GM Waukesha Ford New Holland Freightliner

Nitrite-Free Extended Life	Meets or exceeds these specifications:
Caterpillar EC-1 Cummins CES 14603 Detroit Diesel 93K217 MAN 324 Type SNF MTU 5048 Mercedes DBL 7700 Mercedes 325.3	Behr Radiator ASTM D6210 Navistar CEMS-B1, Type IIIa ASTM DA7583 (John Deere Coolant Cavitation Test)
Meets or exceeds these performance requirements:	
John Deere H24A1, H24C1 PACCAR	Volvo/Mack TMC RP 329

Fleetrite Part Number		Contents
U.S.A.	**CANADA**	
FLTRELCCG	**FLTRELCCGCD**	Fleetrite NOAT Red Extended Life Concentrate Coolant Gallon
FLTRELC5050G	**FLTRELC5050GCD**	Fleetrite NOAT Red Extended Life 50/50 Coolant Gallon
FLTRELCCD	**FLTRELCCDCD**	Fleetrite NOAT Red Extended Life Concentrate Coolant Drum
FLTRELC5050D	**FLTRELC5050DCD**	Fleetrite NOAT Red Extended Life 50/50 Coolant Drum
Fleetrite Part Number		**Contents**
U.S.A.	**CANADA**	
FLTUELCCG	**FLTUELCCGCD**	Fleetrite Nitrite-Free Red Extended Life Concentrate Coolant Gallon
FLTUELC5050G	**FLTUELC5050GCD**	Fleetrite Nitrite-Free Red Extended Life 50/50 Coolant Gallon
FLTUELCCD	**FLTUELCCDCD**	Fleetrite Nitrite-Free Red Extended Life Concentrate Coolant Drum
FLTUELC5050D	**FLTUELC5050DCD**	Fleetrite Nitrite-Free Red Extended Life 50/50 Coolant Drum

* Proper maintenance requires a complete cooling system flush and fill — and subsequent topping off, as needed — with Fleetrite Nitrite-Free Extended Life 50/50 Prediluted Coolant or Fleetrite Nitrite-Free Extended Life Coolant, Fleetrite NOAT Extended Life 50/50 Prediluted Coolant or Fleetrite NOAT Extended Life Coolant and water. For guaranteed protection, no other products or product supplements may be used. For all warranty details, please follow OEM recommendations for specified maintenance.

SCA PRECHARGED FULLY FORMULATED COOLANT

QUALITY ALL-MAKES PARTS YOU CAN DEPEND ON

Fleetrite® SCA precharged fully formulated coolants are formulated for all heavy-duty diesel, gasoline and natural gas engine cooling systems. All Fleetrite prediluted SCA precharged coolants require no SCAs at initial fill and ensure proper chemistry at every top-off.

PRODUCT HIGHLIGHTS

- Works in heavy-duty diesel, gasoline and natural gas engine cooling systems
- Optimum protection against freezing and boil over
- Provides corrosion protection for all cooling system metals and components
- Incorporates nitrite to provide wet sleeve liner protection against cavitation
- Designed to last for the life of the engine when maintained with a high-quality SCA filter system
- Eliminates SCA mixing errors at initial fill
- Phosphate-free formula reduces the risk of scale

SCA Precharged Fully Formulated	Meets or exceeds the following specifications:
Caterpillar	Volvo/Mack
Cummins 90T8-4, CES 14603	MTU 5048
Detroit Diesel 7SE298, 93K217	GM 1899M
Ford ESE-M97B44-A (Sec. 3.1.1 & 3.1.2)	ASTM D4985
John Deere H24A1, H24C1	ASTM D5345
Navistar B-1, Type II	ASTM D6210
Freightliner 48-22880	TMC RP329

Fleetrite Part Number		Contents
U.S.A.	CANADA	
FLTPSCACG	FLTPSCACGCD	Fleetrite Precharged SCA Pink Concentrate Coolant Gallon
FLTPSCA5050G	FLTPSCA5050GCD	Fleetrite Precharged SCA Pink 50/50 Coolant Gallon
FLTPSCACD	FLTPSCACDCD	Fleetrite Precharged SCA Pink Concentrate Coolant Drum
FLTPSCA5050D	FLTPSCA5050DCD	Fleetrite Precharged SCA Pink 50/50 Coolant Drum

GREEN CONCENTRATE COOLANT

QUALITY ALL-MAKES PARTS YOU CAN DEPEND ON

Fleetrite® Green Concentrate Coolant safeguards all makes and models of light-duty diesel and older automotive vehicles against corrosion and rust — all year long. Compatible with all conventional green antifreeze, Fleetrite Green Concentrate Coolant is engineered to protect vehicles against overheating (+276°F) and freezing (-84°F). Fleetrite Green Concentrate Coolant is Navistar aftermarket quality approved.

PRODUCT HIGHLIGHTS

- Maximum freeze-up protection to -84°F, boil-over protection to +276°F
- Provides year-round protection against damaging rust and corrosion
- Compatible with all conventional (Green) antifreeze
- For use in Ford/Chrysler (2000 and earlier), GM (1995 and earlier) and all makes and models of vehicles (1989 and earlier).
- Prediluted Ready Use formula for topping off

Green Concentrate Coolant	Meets or exceeds the following specifications:
ASTM D-3306 ASTM D-4340 Chrysler MS 7170 Ford ESE-M97B-44-A GM 1825M John Deere H24C1 SAE J1034	ASTM D-4985 Caterpillar Cummins 90T8-4 GM 1899M John Deere H24B1 Mack Truck Navistar B1 SAE J1941 TMC RP 302B Volvo/GM Heavy Truck

Fleetrite Part Number		Contents
U.S.A.	CANADA	
FLTGCONVCG	FLTGCONVCGCD	Green Conventional Concentrate Coolant Gallon
FLTGCONV5050G	FLTGCONV5050GCD	Green Conventional 50/50 Coolant Gallon
FLTGCONVCD	FLTGCONVCDCD	Green Conventional Concentrate Coolant Drum
FLTGCONV5050D	FLTGCONV5050DCD	Green Conventional 50/50 Coolant Drum

COOLANT CROSS-REFERENCE CHART

	Market						Fleetrite Coolant Offering			
	Color	Conventional	Fully Formulated SCA Precharged	Hybrid Organic Acid (HOAT)	Nitrited Organic Acid (NOAT)	Organic Acid Extended Life	Fleetrite Green Conventional Coolant	Fleetrite SCA Precharged	Fleetrite NOAT	Fleetrite Nitrite-Free
Fleetrite Green Conventional Coolant	Green									
Fleetrite SCA Precharged Fully Formulated	Pink									
Fleetrite NOAT Extended Life Coolant	Red									
Fleetrite Nitrite-Free Extended Life Coolant	Red									
Concentrate Bottle Part Number							FLTGCONVCG	FLTPSCACG	FLTRELCCG	FLTUELCCG
50/50 Bottle Part Number							FLTGCONV5050G	FLTPSCA5050G	FLTRELC5050G	FLTUELC5050G
Concentrate Drum Part #							FLTGCONVCD	FLTPSCACD	FLTRELCCD	FLTUELCCD
50/50 Drum Part #							FLTGCONV5050D	FLTPSCA5050D	FLTRELC5050D	FLTUELC5050D
PEAK Antifreeze & Coolant	Green									
Chevron Supreme	Green									
Valvoline Zerex Original Formula	Green									
Shell Zone	Green									
Prestone Heavy-Duty Coolant	Green									
Chevron Heavy-Duty Coolant	Purple									
Shell Diesel Ready Coolant	Purple									
Texaco Heavy-Duty Coolant	Purple									
Fleet Charge SCA Precharged Coolant	Pink									
Alliance SCA Precharged Coolant	Pink									
Detroit PowerCool SCA Precharged Coolant	Pink									
Cat Diesel Engine Antifreeze/Coolant (DEAC)	Pink									
Castrol Heavy-Duty Antifreeze with SCA	Pink									
Cummins Fleetguard Fleet Cool	Pink									
Valvoline Zerex G-05 Coolant	Yellow									
Cummins Fleetguard ES Compleat	Blue									
John Deere Cool-Gard Coolant	Green									
Cummins Fleetguard Fleet Cool	Pink									
Valvoline Zerex Extended Life Coolant	Red									
Komatsu Super Coolant AF-NAC	Blue									
Shell Rotella Ultra Extended Life Coolant	Yellow									
Volvo VCS	Yellow									
Chevron Delo Extended Life NF	Yellow									
John Deere Cool-Gard II	Amber									
Final Charge Global Extended Life Coolant	Red									
Alliance OAT Nitrite-Free Extended Life Coolant	Red									
Detroit PowerCool Plus ELC	Red									
Cummins Fleetguard ES Compleat OAT	Red									
Castrol Heavy-Duty Extended Life	Red									
Final Charge NOAT Extended Life Coolant	Red									
Alliance NOAT Extended Life Coolant	Red									
Cat Extended Life Coolant	Red									
Prestone Heavy-Duty Extended Life	Red									
Chevron Delo Extended Life Coolant	Red									
Texaco Extended Life Coolant	Red									
Shell Rotella Extended Life Coolant	Red									

RITE SOLUTIONS

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NAVISTAR®

Mobil

Mobil 1™ Syn Gear Lube LS 75W-90

Supreme Performance Synthetic Multi-Purpose Automotive Gear Lubricant

Product Description

Mobil 1™ Syn Gear Lube LS is a supreme performance, synthetic, multi-purpose, SAE 75W-90 automotive gear lubricant designed to help meet the highest level performance requirements of modern passenger vehicles in all types of operating conditions including limited slip applications, as well as, deliver outstanding power transfer performance. Compared to conventional hypoid gear lubricants, Mobil 1 Syn Gear Lube LS 75W-90 performs exceptionally over a wide range of temperatures. Mobil 1 Syn Gear Lube LS 75W-90 achieves this through a unique proprietary formulation, that deliver optimized viscosity-temperature properties together with the highest level of inherent formulation stability and helps to protect against thermal and oxidative degradation, wear and corrosion, viscosity loss associated with premature shearing. It also can be used in extended service and for aiding in fuel economy performance.

Features and Potential Benefits

Mobil 1 Syn Gear Lube LS 75W-90 combines wax-free synthesized hydrocarbon base oils and a specially designed extreme-pressure, limited-slip, sulfur-phosphorous additive system to help provide a significantly higher level of performance in rear axles and differentials versus conventional fluids. Great film strength at higher operating temperatures, reduced fluid friction and low-temperature application down to -50ºC helps to provide significant advantages versus conventional mineral oil formulations. It helps to reduce wear and spalling under the high speed, high torque and high horsepower conditions in competitive racing and high performance automobiles. This unique, high technology final drive gear lubricant has demonstrated outstanding performance including fuel economy, extended drain, long-term friction retention, low-temperature capability and improved differential/axle durability and cleanliness. Key features and potential benefits include:

Features	Advantages and Potential Benefits
Exceptional thermal stability and resistance to high temperature oxidation	Helps to extend gear and bearing life due to minimal deposits Long seal life Potential extended oil drain/service intervals
Outstanding protection against low speed/high torque wear and against high speed scoring	Capability to handle some of the severest driving conditions while delivering smooth efficient and reliable performance
Exceptional shear stability	Helps to retain viscosity and film strength under severe operating conditions to prevent wear
Excellent rust, staining and corrosion protection of copper and its alloys	Helps to reduce wear Long component life
Enhanced frictional properties	Improved fuel economy and reduced operating costs
Outstanding low temperature fluidity versus mineral oils	Helps to reduce wear at start up and ease of start up even in arctic conditions
Good resistance to foaming	Helps to maintain film strength for reliable lubrication
Compatible with typical automotive seals and gaskets	Helps to minimize leakage and reduce contamination
Excellent limited-slip performance	Helps to reduce chatter and improve traction

Applications

- Mobil 1 Syn Gear Lube LS 75W-90 is SUITABLE for use in modern high performance automobiles like SUV's, Vans and Light duty trucks requiring API GL-5 level performance

- Mobil 1 Syn gear Lube LS 75W-90 is intended for initial fill, topping-off or refilling differentials, final drives, transfer cases and other gear applications where lubricants meeting API Service GL-5 and multi-purpose or mild EP gear lubricants are recommended
- Not recommended for automatic, manual or semiautomatic transmissions for which engine oil or automatic transmission fluids are recommended
- Where extended service intervals and warranties are required

Specifications and Approvals

Mobil 1 Syn Gear Lube LS meets or exceeds the requirements of:	75W-90
API GL-5	X

Typical Properties

Mobil 1 Syn Gear Lube LS	
SAE Grade	75W-90
Viscosity (ASTM D445)	
cSt @ 40ºC	103
cst @ 100ºC	14.6
Viscosity Index	146
Pour Point, ºC (ASTM D97)	-39
Flash Point, ºC (ASTM D92)	150
Density@15.6 ºC g/ml (ASTM D4052)	0.859

Health and Safety

Based on available information, this product is not expected to produce adverse effects on health when used for the intended application and the recommendations provided in the Material Safety Data Sheet (MSDS) are followed. MSDS's are available upon request through your sales contract office, or via the Internet. This product should not be used for purposes other than its intended use. If disposing of used product, take care to protect the environment.

7-2014

Exxon Mobil Corporation
3225 Gallows Road
Fairfax, VA 22037

1-800-ASK MOBIL (275-6624)

Typical Properties are typical of those obtained with normal production tolerance and do not constitute a specification. Variations that do not affect product performance are to be expected during normal manufacture and at different blending locations. The information contained herein is subject to change without notice. All products may not be available locally. For more information, contact your local ExxonMobil contact or visit www.exxonmobil.com
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SHP® Syngear FE

Premium Synthetic, Fuel-Efficient Automotive Gear Lubricant, API GL-5/MT-1

Kendall® SHP Syngear FE is a premium quality, synthetic, fuel-efficient (FE) API GL-5 automotive gear lubricant designed for use in passenger car and truck axles with hypoid gear sets operating in extreme temperatures or under severe driving conditions. It has been specifically formulated to provide improved fuel economy compared to typical mineral SAE 80W-90 or synthetic SAE 75W-90 gear oils.

SHP Syngear FE is formulated to provide long service life, extended gear life and better fuel economy in automotive differentials operating under varying conditions of speed, load, temperature and torque. The carefully balanced formulation is designed to minimize oxidative sludge and varnish formation, reduce wear, prevent scoring damage, and protect against metal fatigue and spalling damage under shock-load conditions. The full-synthetic formulation provides enhanced oxidation resistance and thermal stability at high temperatures and better low-temperature properties compared with conventional mineral oil-based automotive gear oils, resulting in longer service intervals and better performance over a wider temperature range. In standard industry and commercial fleet tests, this product has shown a fuel savings of 1.0-1.5% compared to typical synthetic SAE 75W-90 gear oils.

SHP Syngear FE is fully approved for 500,000-mile drain intervals in drive axles in linehaul service under Dana®/Eaton® Roadranger® extended warranties.

Applications

- Service fill of conventional differentials on passenger cars and trucks
- Top-off only of limited-slip differentials on passenger cars and light trucks(1)
- Service fill of differentials, final drives and transfer cases in some off-highway equipment
- Non-synchronized manual transmissions in trucks, buses and heavy equipment where the manufacturer specifies an API GL-5 or MT-1 gear oil

(1) ***Note:*** *For complete drain and refill, many limited-slip differentials may require the manufacturer's specified gear lubricant or supplemental additive. Refer to the owner's manufal for specific requirements.*

SHP Syngear FE meets or exceeds the requirements of:

- API Service GL-5, MT-1
- International (Navistar) TMS 6816

CONTACT INFORMATION

Phillips66 Lubricants.com

U.S. Customer Service:
1-800-368-7128

Technical Hotline:
1-877-445-9198

International Customer Service:
1-832-765-2500

E-mail address:
kendallmotoroil@p66.com

- Mack GO-J Plus
- Meritor O76-N
- MIL-PRF-2105E
- SAE J2360

SHP Syngear FE is approved for service fill under the following OEM specifications:

- Dana SHAES-256 Rev C, SHAES-429

Features/Benefits

- Extended drain, all-season performance
- Outstanding oxidation resistance and thermal stability to minimize sludge and varnish formation
- Excellent thermal durability and extreme-pressure properties for extended gear life
- High load-carrying capacity for protection against scuffing and wear
- High shear stability
- Outstanding low-temperature properties
- Protects against rust and corrosion
- Good foam resistance
- Higher fuel efficiency compared to typical conventional SAE 80W-90 and synthetic SAE 75W-90 gear oils

SHP® Syngear FE

Typical Properties

SAE Grade	**75W-90**
Specific Gravity @ 60°F	0.891
Density, lbs/gal @ 60°F	7.42
Color, ASTM D1500	L 2.0
Flash Point (COC), °C (°F)	215 (419)
Pour Point, °C (°F)	-45 (-49)
Viscosity, Brookfield	
cP @ -40°C	90,000
Viscosity, Kinematic	
cSt @ 40°C	103
cSt @ 100°C	15.0
Viscosity Index	152

Health and Safety Information

For recommendations on safe handling and use of this product, please refer to the Material Safety Data Sheet via *http://w3apps.phillips66.com/NetMSDS.*

Maxtron® GL

Full Synthetic EP Gear Lubricant
Maxtron Enviro-Edge®GL 75W-90 and Maxtron® GL 80W-140

General Description

Maxtron® GL is a full synthetic multi-purpose, extreme pressure, GL-5 gear lubricant specially formulated for extended drain, durability, and all season performance.

Maxtron GL has outstanding shear resistance, oxidation and thermal stability to minimize sludge and varnish in addition to low temperature flow properties. The additive system provides excellent load carrying that reduces wear along with, rust, corrosion, foam and seal swell control.

Maxtron Enviro-Edge GL 75W-90 exceeds the fuel economy performance of many 75W-90 synthetics and especially conventional mineral oil based 80W-90 and 85W-140 gear oils. This formulation demonstrated fuel economy savings, low temperature flow performance and high temperature gear protection.

Expect excelent performance in these applications:

API GL-5, MT-1
Mil-PRF-2105E, SAE J2360
DANA Shaes 256 Rev C, 429 Rev A
Eaton PS-163, 037,109
Arvin Meritor (Rockwell) 076-B,E,N,Q, and 0-80
Navistar TMS 6816
Mack GO-J Plus, GO-J
Harnischfeger (P&H) 474
General Electric D50E9C
Spicer axles

Features and Benefits

- **Proven Fuel Economy:** Maxtron Enviro-Edge GL 75W-90 demonstrates over 1% improvement over other full synthetic 75W-90 gear lubricants in conjunction with Maxtron MT 50 in the manual transmission and up to 3% over conventional SAE 90 and 85W-140 mineral gear lubricants.
- **All Weather Protection:** Outstanding oil pumpability at cold temperatures for quicker lubrication and less gear resistance while maintaining a heavy lubrication film at high operating temperatures.
- **Oil Durability:** Improved wear and oxidation resistance in extended drain service resulting in longer oil and equipment life.
- **Lower Operating Costs:** Extending drain intervals under OEM programs leads to more driving time, less down time for repairs and oil changes allowing better equipment utilization and profits.
- **Meets OEM Extended Drain/Warranty:** Original Equipment Manufacturers (OEMs) such as Eaton, Meritor/Rockwell, and Dana each approve extended warranty coverage (up to 750,000 miles) and longer drain intervals (up to 500,000 miles) when using Maxtron GL. See OEM for details.

Maxtron GL has formal approval from Roadranger, Dana, and Eaton for extended drain and warranties.

For maximum performance and compatibility, do not mix mineral and synthetic gear lubricants

PDS-244-14

Maxtron® GL

Full Synthetic EP Gear Lubricant
Maxtron Enviro-Edge® GL 75W-90 and Maxtron® GL 80W-140

Typical Application

Maxtron® GL can be used in differentials, axles, final drives and manual transmissions calling for a GL-5/MT-1/EP gear lubricant:

- Trucks, Tractors, Construction.
- On road/off road
- Hypoid and bevel gear differentials
- Limited slip (top off only in cars/light trucks)
- Industrial equipment

Typical Customer

Owners and operators of:

- Truck, bus, and off-highway equipment that will benefit from a full synthetic EP gear lubricant.
- Fleets interested in fuel economy improvement.
- Fleets interested in extended oil drain intervals and reduced down time.
- Equipment that operates over a wide temperature range.

Typical Properties

SAE Grade	Maxtron Enviro-Edge GL 75W-90	Maxtron GL 80W-140
API Gravity/lbs gal.	27.3/7.42	23.6/7.51
Viscosity @ 40°C, cSt (SUS)	103 (620)	284/1,471
Viscosity @ 100°C, cSt (SUS)	15.0 (72)	30.6/149
Viscosity Index	152	146
Brookfield Viscosity, cP @ -40 °C	90,000	-
Brookfield Viscosity, cP @ -26 °C	-	75,000
Pour Point °C/°F	<-45/<-49	<-40/<-40
Flash, COC, °C/°F	215/420	202/395
Foam, Seq I, II, III	Pass	Pass
Copper Strip Corrosion	Pass	Pass

The typical properties listed reflect the general characteristics of the product, and are not manufacturing specifications. Normal batch-to-batch variations should be expected.

Health & Safety

A complete safety data sheet is available by calling 1-651-355-8438 or visit www.cenex.com.

Previous Name: **Shell Spirax ASX-R 75W-90**

Shell Spirax *S6 AXRME 75W-90*

Superior performance, extended drain synthetic, GL-5 axle oil for Roadranger, Meritor and others

Shell Spirax S6 AXRME 75W-90 is a fuel-efficient axle fluid, designed to provide ultimate protection to the latest heavy-duty axles calling for API GL-5 type products. Specially formulated with synthetic base oils and additive technology that provide improved lubrication of the drive train, lowers the operating temperature and helps promote longer life for the equipment. Shell Spirax S6 AXRME 75W-90 is capable of extended oil drain and is approved by several OEMs for extended drain specifications. Extensive fleet testing has demonstrated a fuel efficiency improvement of over 1% when compared to several products in the same application.

DESIGNED TO MEET CHALLENGES

Performance, Features & Benefits

- **Fuel efficient formulation**
  Proven fuel efficiencies in both standard industry and commercial fleet testing methods of over 1%.
- **Longer oil drain capability**
  Meets the requirements of Dana SHAES 256 Rev C, (500,000 mile oil drains, with warranty for 750,000 miles), which documents the long drain capability of the fuel efficient formulation.
- **Longer equipment life**
  Excellent protection against gear wear and pitting, helps prevent premature failures. Outstanding oxidation resistance also helps prevent damage to seals due to deposit formation.
- **Less lubricant usage**
  Excellent static and dynamic seal compatibility that meets or exceeds a number of leading OEM requirements, which helps minimize seal leaks. The extended drain capabilities help maximize oil drain intervals resulting in less overall lubricant usage during the life of the equipment.
- **Recognized by leading equipment manufacturers**
  A number of leading equipment manufacturers recognize the benefits of Shell Spirax S6 AXRME 75W-90 and have formally approved it against their specifications.

Main Applications

- **Drive axles in heavy duty on-highway trucks**
  Heavy duty axles and other applications where a 75W-90 API GL-5 extreme pressure (EP) mineral or synthetic gear oil is recommended.
  Note: For Eaton Roadranger Transmissions Use Spirax S6 GME 50

Specifications, Approvals & Recommendations

- ArvinMeritor O76-N
- DANA SHAES-256 Rev C
- International TMS 6816
- Mack GO-J Plus
- API GL-5, MT-1
- SAE J2360
- US Military MIL-PRF-2105E

For a full listing of equipment approvals and recommendations, please consult your local Shell Technical Help Desk.

Typical Physical Characteristics

Properties			Method	Shell Spirax S6 AXRME 75W-90
SAE Viscosity Grade			SAE J306	75W-90
Appearance				Amber
Kinematic Viscosity	@40°C	cSt	ASTM D445	103
Kinematic Viscosity	@100°C	cSt	ASTM D445	15
Viscosity	@-40°C	cP	ASTM D2983	90000
Viscosity Index			ASTM D2270	152
Density	@15.6°C	g/l	ASTM D1298	891
Density	60°F	lbs/gal.	ASTM D1298	7.42
Flash Point (COC)		°C/ (°F)	ASTM D92	215 / (420)
Pour Point		°C/ (°F)	ASTM D97	<-45 / (<-49)

These characteristics are typical of current production. Whilst future production will conform to Shell's specification, variations in these characteristics may occur.

Health, Safety & Environment

- **Health and Safety**

  Shell Spirax S6 AXRME 75W-90 is unlikely to present any significant health or safety hazard when properly used in the recommended application and good standards of personal hygiene are maintained.

  Avoid contact with skin. Use impervious gloves with used oil. After skin contact, wash immediately with soap and water.

  Guidance on Health and Safety is available on the appropriate Material Safety Data Sheet, which can be obtained from your Shell representative.

- **Protect the Environment**

  Take used oil to an authorised collection point. Do not discharge into drains, soil or water.

Additional Information

- **Advice**

  Advice on applications not covered here may be obtained from your Shell representative.

Product Information

A PRODUCT OF VALVOLINE, A DIVISION OF ASHLAND INC.

VALVOLINE SYN GARD™ FE GEAR OIL

Valvoline Syn Gard FE Gear Oil is a superior sulfur-phosphorus extreme pressure gear lubricant formulated with synthetic basestocks and exclusive additives to provide excellent wear control and fuel economy enhanced performance. It is designed to provide outstanding extreme pressure protection, load carrying capacity, anti-foam performance, corrosion protection, and thermal stability protection in the most demanding applications.
Valvoline Syn Gard FE Gear Oil has been shown to provide SAE J1321/TMC RP 1102 Type II real fuel economy improvement over competitive synthetic products and is specifically recommended for use in Class 8 trucks.

Valvoline Syn Gard FE Gear Oil Advantages:

- **Fuel Economy:** Provides measureable gains in fuel economy over competitive synthetic products.
- **Thermal Protection:** Provides outstanding thermal stability for cleanliness and longer service life.
- **Corrosion Protection:** Protects parts from rust and corrosion.
- **Wear Protection:** Outstanding durability for longer oil drains.
- **Flow Properties:** Provides excellent low temperature protection.

Approvals/Performance Levels

API GL-5/MT-1
MIL-PRF-2105E
SAE J2360
Scania STO 1:0
Meritor 076-N pending
Meets ZF 07A
Suitable for use in commercial applications requiring extended drain fluids with drain intervals up to and including 500K miles

Tests and Properties

SAE Viscosity	75W-90
Vis @ 100°C (cSt)	15.5
Vis @ 40°C (cSt)	89
Viscosity Index	185
Spec Gravity @ 60°F	0.859
Density (lbs/gal)	7.16
Flash COC (°C)	220
Pour Point (°C)	-48
Phosphorus, wt.%	0.13
Sulfur, wt.%	2.4

Part Numbers

5 Gallon Pail	728711
55 Gallon Drum	728460

Refer to Valvoline's Material Safety Data Sheet for health and safety instructions.

Effective Date:	Replaces:	Author's Initials:	Pages	Code
1/25/12	11/1/11	JRT	1	SGFE1201