THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

SOUTHERN RESEARCH INSTITUTE

ETV Joint Verification Statement

TECHNOLOGY TYPE:	Fuel Efficient Rear Axle Lubricant
APPLICATION:	Light-Duty Trucks and SUVs
TECHNOLOGY NAME:	ConocoPhillips Fuel-Efficient High-Performance (FEHP) SAE 75W90 Rear Axle Gear Lubricant
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The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the purchase, design, distribution, financing, permitting, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups that consist of buyers, vendor organizations, and permitters, and with the full participation of individual technology developers. The program evaluates the performance of technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests, collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Greenhouse Gas Technology Center (GHG Center), one of six verification organizations under the ETV program, is operated by Southern Research Institute in cooperation with EPA's National Risk Management Research Laboratory. The GHG Center has completed the performance verification of the ConocoPhillips Fuel-Efficient High-Performance (FEHP) Society of Automotive Engineers (SAE) 75W90 Rear Axle Gear Lubricant. This verification statement provides a summary of the test results for the lubricant.

TECHNOLOGY DESCRIPTION

The transportation sector accounted for approximately 32 percent of CO_2 emissions from fossil fuel combustion during 2001. The US EPA reports that in 2001, automobiles and light-duty trucks produced approximately 1.074 x 10^9 and 1.87 x 10^7 metric tons of carbon dioxide (CO_2) equivalents from the combustion of gasoline and diesel fuel, respectively. Combustion of gasoline and diesel fuel in automobiles and light-duty trucks was responsible for approximately 73 percent (57 percent from gasoline and 16 percent from diesel) of total transportation related CO_2 emissions in the US during 2001. Small fuel efficiency or emission rate improvements are expected to have a significant beneficial impact on nationwide greenhouse gas emissions because of the large quantity of fuel consumed.

ConocoPhillips has developed the Fuel-Efficient High-Performance (FEHP) SAE 75W90 Rear Axle Gear Lubricant in partnership with an axle manufacturer (Visteon Corporation) and an additive supplier (Ethyl Petroleum Additives, Ltd.). The product is marketed as a fuel efficient, high performance, multi-grade gear lubricant for light-duty trucks, automobiles, and sport utility vehicles (SUVs). ConocoPhillips states that the product consists of a lower viscosity, synthetic base lubricant with optimized fluidity and friction modifiers when compared to standard axle lubricants. The developers report incremental fuel economy improvements of 0.1 to 0.2 miles per gallon [mpg] with FEHP when compared to standard lubricants.

According to ConocoPhillips, the FEHP offers the following benefits:

- Improved axle efficiency,
- Reduced temperature under severe towing,
- Reduced spin losses, and
- Improved thermal and oxidative stability.

ConocoPhillips claims that the properties of the FEHP, including product durability, allow it to be a replacement for standard SAE 75W140 rear axle gear lubricant typically specified by some automobile manufacturers in light-duty trucks with FEHP rated at 75W90. Table 1 summarizes typical FEHP physical properties as provided by ConocoPhillips.

Table 1: FEHP Fluid Properties[a]				
Specified Test	**Specified Method**	**Minimum Value Allowed**	**Maximum Value Allowed**	**Typical Values**
Kinematic Viscosity at 100 °C, cSt	ASTM D445	17	18.5	17.65
Kinematic Viscosity at 40 °C, cSt	ASTM D445	--	--	108.7
Viscosity Index	ASTM D2270	172	--	179.5
Pour Point, °C	ASTM D97	--	-42	-48
Sulfur, %	ASTM D1552	1.23	2.21	1.8
Phosphorus, %	ASTM D4951	0.07	0.123	0.09
Nitrogen, %	ASTM D4629	0.083	0.263	0.14
Boron, %	ASTM D4951	0.006	0.19	0.012
Moisture, %	Karl Fischer Titration, ASTM D6304	--	0.10	0.04
Flash Point, °C	ASTM D92	150	--	193
Density @ 60 °F, Kg/L	ASTM D4052	--	--	0.866
Copper corrosion	ASTM D130	--	2b	1b

[a]*Provided by ConocoPhillips. Not verified by the GHG Center.*

VERIFICATION DESCRIPTION

The goal of the performance verification testing for the ConocoPhillips FEHP rear axle gear lubricant was the determination of a potential small change in fuel economy resulting from the use of the FEHP lubricant when compared to a standard or reference lubricant. The test program was completed in accordance with the requirements of the Test and Quality Assurance Plan for ConocoPhillips Fuel-Efficient High-Performance SAE 75W90 Rear Axle Gear Lubricant (SRI/USEPA-GHG-QAP-28), March, 2003. The sole verification parameter for testing of the ConocoPhillips FEHP rear axle gear lubricant is the change in fuel economy (mpg). Emissions of greenhouse gases and other pollutants were also determined.

Fuel economy testing was completed at Southwest Research Institute's (SwRI) Department of Emissions Research (DER). The test site for the FEHP fuel economy change determination was SwRI's light-duty vehicle Chassis Dynamometer #7. The dynamometer is equipped with a constant volume sampling system, an array of emissions analyzers, a fuel supply cart, and ambient monitoring and control equipment. Testing conditions (ambient conditions, test fuel, vehicle driver, etc.) were consistent throughout the test period.

Testing was completed on a 2003 Ford F-150 Supercrew V8 with a straight beam axle. This vehicle was determined to be representative of a large portion of straight beam axle vehicles in current production, although a portion of vehicles in the future are likely to make use of independent rear wheel suspensions. The vehicle was operated on the chassis dynamometer over two test cycles for each test run using the Federal Test Procedure (FTP) (40 CFR 86.115) and the Highway Fuel Economy Test (HFET) (40 CFR Part 600, Appendix I) to determine fuel economy. Carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), total hydrocarbons (THC), and methane (CH_4) emission rates for each test phase were determined through analysis of exhaust samples using the Horiba VETS-9200 control system, emission analyzers and a constant volume sampling system. Pollutant mass emission rates were calculated in accordance with 40 CFR 86.144. Non-methane hydrocarbon (NMHC) emission rates were calculated from THC and CH_4 emissions in accordance with the same standard. Vehicle fuel economy was calculated using the methods specified in 40 CFR 600.113. This method uses a carbon balance based on the carbon content of test fuel used and carbon exhaust emissions measured during each test phase to determine fuel economy.

The test period consisted of an initial set of five valid test runs using the reference lubricant (75W140, as recommended by the manufacturer). Six runs using the 75W90 FEHP lubricant were then completed. Six additional runs using fresh reference lubricant were completed after the FEHP runs to determine if a change in fuel economy occurred as a result of mileage accumulation effects and vehicle break-in. The mean fuel economies for each lubricant type were compared to determine the fuel economy change. A statistical analysis was applied to the data sets to determine the statistical significance of the measured fuel economy change. A confidence interval was calculated for the observed fuel economy change.

The test vehicle was acquired on March 26, 2003, with vehicle setup, axle lubricant change, and mileage accumulation occurring between March 26 and April 1, 2003. The fuel economy testing verification period started on April 2, 2003. Testing was completed on May 31, 2003.

Quality assurance audits of the test facility laboratory were completed by the GHG Center field team leader during testing. The GHG Center completed: (1) a technical systems audit to assure the testing was in compliance with the test plan; (2) a performance evaluation audit to ensure that measurement systems employed were adequate to produce reliable data; and (3) a data quality audit of at least 10 percent of the test data to assure that the reported data and data reduction procedures accurately represented the data generated during the test. In addition to the quality assurance audits performed by the GHG Center, EPA QA personnel conducted a quality assurance review of the Verification Report and a quality systems audit of the GHG Center's Quality Management Program.

The GHG Center has made every attempt to obtain a reasonable and representative set of data to examine fuel economy changes resulting from the use of the FEHP lubricant in light-duty trucks. However, these results may not represent performance at significantly different operating conditions or for different vehicle and axle types.

VERIFICATION OF PERFORMANCE

A total of seventeen valid fuel economy tests were completed on the test vehicle during the test period. Fuel economy data was normalized to account for a slight upward drift in fuel economy between the initial and final reference lubricant runs. Table 2 presents a summary of the normalized mean fuel economy results and the standard deviation for each set of lubricant tests.

Table 2: Normalized Fuel Economy Test Results	
Test Run ID	**Normalized Fuel Economy (mpg)**
Reference Lubricant- Initial	
Mean	**17.396**
Standard Deviation	**0.0414**
FEHP Lubricant	
Mean	**17.566**
Standard Deviation	**0.0307**
Reference Lubricant- Final	
Mean	**17.398**
Standard Deviation	**0.0447**

Analysts completed a statistical analysis of the fuel economy data to determine whether a statistically significant change in fuel economy had occurred. A confidence interval was also calculated for the fuel economy change. The following summarizes the verification results:

- The GHG Center's evaluation of the verification test results shows a statistically significant improvement in overall fuel economy resulting from the use of the FEHP rear axle lubricant on a 2003 Ford F-150 with beam axle.
- The mean measured fuel economy improvement resulting from the use of the ConocoPhillips FEHP 75W90 rear-axle lubricant is **0.169 mpg ± 0.0410 mpg**. The error specified represents the 95-percent confidence interval of the measured fuel economy change data.
- A **0.97 percent** improvement in overall vehicle fuel economy occurred with the use of the FEHP lubricant when compared to the mean vehicle fuel economy with the reference lubricant.

Greenhouse gas and other pollutant emissions from the test vehicle were measured during use of the reference lubricant and FEHP lubricant as part of the fuel economy test procedure. The following tables present a summary of the mean pollutant emission rates observed for both the FTP and HFET test cycles.

Table 3a: Greenhouse Gas and Other Pollutant Emissions – FTP						
	THC	**CO**	**NO_x**	**CO_2**	**NMHC**	**CH_4**
Test Run ID	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi
Reference Lubricant-Initial						
Mean	*0.105*	*0.952*	*0.035*	*584.192*	*0.091*	*0.014*
Standard Deviation	*0.005*	*0.028*	*0.002*	*1.746*	*0.005*	*0.001*
FEHP						
Mean	*0.106*	*0.964*	*0.035*	*575.927*	*0.092*	*0.014*
Standard Deviation	*0.005*	*0.071*	*0.003*	*1.199*	*0.004*	*0.000*
Reference Lubricant-Final						
Mean	*0.111*	*0.990*	*0.036*	*580.072*	*0.095*	*0.015*
SD	*0.004*	*0.070*	*0.002*	*1.398*	*0.005*	*0.001*

Table 3b: Greenhouse Gas and Other Pollutant Emissions – HFET						
	THC	**CO**	**NO_x**	**CO_2**	**NMHC**	**CH_4**
Test Run ID	g/mi	g/mi	g/mi	g/mi	g/mi	g/mi
Reference Lubricant-Initial						
Mean	*0.023*	*0.145*	*0.007*	*380.334*	*0.015*	*0.007*
Standard Deviation	*0.004*	*0.039*	*0.000*	*1.461*	*0.004*	*0.001*
FEHP						
Mean	*0.025*	*0.164*	*0.008*	*376.320*	*0.017*	*0.008*
Standard Deviation	*0.003*	*0.018*	*0.001*	*0.880*	*0.002*	*0.001*
Reference Lubricant-Final						
Mean	*0.025*	*0.168*	*0.008*	*378.109*	*0.017*	*0.008*
Standard Deviation	*0.003*	*0.030*	*0.001*	*2.469*	*0.002*	*0.001*

Emissions are consistent throughout each group of test runs, with coefficients of variation below 0.3. A comparison of mean gram per mile emission rates for the FEHP and reference lubricants indicates a reduction in CO_2 emissions during the FEHP runs when compared to the reference lubricant runs for both the FTP and HFET cycles. Carbon dioxide constitutes the majority of vehicle exhaust. Therefore, a reduction in CO_2 emissions is expected as a result of the improvement in fuel economy attributed to the use of the FEHP lubricant.

Signed by Hugh W. McKinnon, 9/2003

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