Demonstration of the On-The-Road Use of Biodiesel

IDWR/University of Idaho
Cummins Powered 1992 Dodge
161,000 km (100,000 m) On-Road Test

Contract No. DWR-92-03-81-102-6

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ABSTRACT

A heavy duty pickup truck with a 5.9L diesel engine was targeted to operated on a blend of 20% methyl ester of rapeseed oil (RME) and 80% 2-D diesel (2-D) for 161,000 km (100,000 miles). The actual blend used was 27.9% RME. The engine was unmodified, but modifications were made to the vehicles for the convenience of the test. Fuel mixing was done on-board to extend the driving range to over 5,000 km (3,100 miles) between Biodiesel fill ups. Rusting of the mild steel fuel tanks contributed to fuel filter plugging which was eventually solved by changing to stainless steel tanks and switching to a different fuel supplier.

Chassis dynamometer testing, injector coking, engine compression, injector valve opening pressures, and engine oil analyses were done at regularly scheduled intervals to monitor the engine performance parameters. RME produced 5 percent less power than 2-D, while 20RME produced 1.5% percent less power than 2-D. Smoke density was reduced 32 percent with RME, while 20RME increased smoke density 6.6 percent higher than that of 2-D. The results of the oil analysis showed that there was no unusual deterioration of the engine, or any unusual change in used oil composition from using the biodiesel fuel. Using aluminum and iron as comparison analysis, the test vehicle averaged 2.2 ppm for aluminum and 8.0 ppm for iron, the first check vehicle averaged 2.4 ppm for aluminum and 8.5 ppm for iron, the second check vehicle averaged 5.4 ppm for aluminum and 20.0 ppm for iron, and a third check vehicle averaged 5.7 ppm for aluminum and 64 ppm for iron (the third of four samples showed iron at 183 ppm with the others at 20-28 ppm.) Engine compression and injector valve opening pressure remained constant throughout the test.

Emissions tests with a chassis transient dynamometer at the Los Angeles Metropolitan Authority Emissions Test Facility resulted in a decrease in HC (20 percent), CO (25 percent), NOx (2.6 percent), PM (10.9 percent), and there was no difference in CO_2 with 20RME compared to 2-D.

When the vehicle reached 163,800 km (101,785 miles) the diesel engine was removed from the truck and shipped to Cummins Engine Company in Columbus, Indiana for analysis. The condition of the engine obviously reflected the light load condition of use in the pickup. However, it was generally considered to be in a condition which could be characterized as good or better than that which would have been expected with diesel fuel. Engine parts were clean and showed little wear. Adverse effects were hardening of the crankshaft seals which made a slight depression where they made contact with the shaft; and rusting of the fuel filter attachment stud. The fuel pump although showing varnish was found to be in good condition in the bench test.

INTRODUCTION

During the past decade, the United States has become increasingly dependent upon imported oil to meet its energy demands. In 1989, approximately 2,940 million barrels of oil, nearly 45% of total U.S. consumption, were imported. Since the Persian Gulf Crisis, there has been heightened interest in development of alternative liquid transportation fuels. Research teams at several universities and the United States Department of Agriculture have shown that the American farmer can help reduce the United State's dependence on imported oil by using excess agricultural production to grow oil-seed fuels. Diversion of only 10% of the cropland to the production of oil-seed fuels could provide all the diesel fuel required for American agriculture. Diversion of approximately 25% of the cropland could produce 218 million barrels of oil which could provide a third of the United State's transportation diesel while reducing our foreign trade deficit by over $5 billion.

Alcohol ester of vegetable oil (Biodiesel) fuels are produced by reacting the oil extracted from rapeseed, sunflowers, soybeans or other oil-seed crops with either methanol or ethanol and a catalyst. These alcohol esters of vegetable oil can be substituted for diesel fuel in unmodified diesel engines without reducing either performance or expected engine life. Also, it has been shown in Europe that a blend of straight rapeseed oil and diesel can work in unmodified precombustion chamber diesel engines. Farm-grown fuels contain very low levels of both sulfur and aromatic compounds which help reduce emissions of SO_2 and volatile organic compounds. Also, biodiesel fuels or blends of them with diesel have been shown to reduce particulate emissions from diesel engines. Thus, these fuels have the potential of reducing pollution in cities with particulate emission problems.

Much interest has been generated in the use of alternative fuels for transportation. The Clean Air Act Amendment of 1990 mandates a phase-in plan for adoption of clean fuels that are not harmful to the environment. The Energy Policy Act of 1992 also mandates fleet operators to begin purchasing alternative fueled vehicles as a percentage of all new vehicles purchased starting in model year 1996. Changes in EPA exhaust emissions requirements for diesel engines have also created much interest in the use of Biodiesel. Legislation and federal policies of these types will significantly increase the attractiveness of the use and expedite the commercialization of biofuels, including ethanol and vegetable oils. Increased use of renewable fuels can reduce U.S. dependence on imported oil and help improve air quality by reducing harmful gaseous and particulate emissions.

Emissions from compression ignition engines fueled with vegetable oil contain negligible levels of sulfur dioxide responsible for acid rain. Vegetable oils are also more environmentally friendly in the case of a spill. The fuel is biodegradable and will quickly break down, thus preventing long-term damage to soil or water (Zhang et al., 1995).

Vegetable oil as an alternative to diesel fuel has been studied at the University of Idaho since 1979. Researchers at the UI have pioneered the use of rapeseed oil as a diesel fuel substitute. Through this and other research, it has been shown that raw rapeseed oil is best used for fuel in precombustion chamber type diesel engines as a blend with diesel. Most diesel engines in use in the United States are of the direct-injection type. For these engines, it has been found that the rapeseed oil should be transesterified before being used as a diesel-fuel substitute. Methyl ester of rapeseed (RME) can be substituted for diesel fuel in unmodified diesel engines without significant reduction in engine performance.

OBJECTIVES

Past research has focused on the development and testing of Biodiesel in controlled environments. The objective of this project was to determine if Biodiesel is a viable transportation fuel using an on-the-road pickup truck. Specific objectives for achieving this goal were to:

- Operate a pickup for 161,000 km (100,000 miles) with a blend of 20 percent rapeseed methyl ester (RME), 80 percent number two diesel (2-D) [20RME].

- Design an on-board fuel mixing system to maximize the travel range, provide for heating the fuel to keep it from congealing, and minimize operator intervention in the fuel-blending process.

- From dynamometer testing, both chassis and steady state, determine the percent difference in power, opacity, and fuel economy compared to that of 2-D.

- Conduct pending ASAE fuel standard tests for 20RME, number two diesel, and 100% RME.

- Compare regulated emissions data including total hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), and particulate matter (PM), for RME, 20RME, and diesel control fuel.

LITERATURE REVIEW

Initial studies at the University of Idaho used 100 percent raw vegetable oil resulting in incomplete combustion, causing severe engine deposits, ring sticking, injector coking, contamination to the engine oil, and, inevitably, to engine failure (Peterson et al., 1983a and Peterson et al., 1983b.) Raw vegetable oils are susceptible to gum formation, causing carbon buildup in the combustion chamber and around the injector nozzle tips. Vegetable oils have a viscosity 11 to 17 times higher than that of diesel fuel, which causes droplets produced by the fuel injector to be much larger than those produced when using diesel fuel. As a result, less oil comes in contact with oxygen, the unburned fuel spray impinges on the cylinder wall washing away the lubricating oil film, and causes thickening of the crankcase oil.

After these first tests, the vegetable oil was modified through a process called transesterification (Peterson et al., 1989, Perkins et al., 1991, Peterson et al., 1997). Transesterification is a process which involves reacting vegetable oil with an alcohol in the presence of a catalyst to produce an ester and a glycerol layer. Ester viscosities are more suitable for use as a diesel-engine fuel.

Even today, after a decade of research and development with esterified fuels, there is the misconception by the general public that the engine failure and excessive injector coking originally reported with raw vegetable oil has not been solved. With this background, the literature review will focus mainly on esterified fuels with a major emphasis on power, opacity, and emissions reported from on-road tests performed with Biodiesel.

Schumacher et al. (1996) ran two Cummins B5.9L engines, fueled with 100% soy methyl ester biodiesel, in Dodge pickups. A reduction of power was noted when the engines were tested using a chassis dynamometer. A 1991 pickup was driven 110,451 km (68,631 miles) and a 1992 pickup was driven 177,022 km (109,996 miles). The pickups averaged 6.9 km/L (16.6 mpg.) Schumacher et al. (1996) found that CO, HC and particulate matter were lower for Biodiesel and NOx was higher compared to diesel fuel in the same engine. They also found that materials (Fe, Pb, Si) from engine wear, based on oil analysis, were lower for biodiesel compared to diesel.

Schumacher et al. (1993) have fueled two Dodge diesel pickups, one a 1991 and one a 1992, with 100 percent soydiesel. They added a fuel tank to the bed of each pickup and installed stainless steel heat exchangers for cold weather operation. The soydiesel fuel tanks and fuel lines were insulated. Two 110-volt thermostatically controlled flat mat heating pads were placed beneath the soydiesel tank for heating during cold weather when the vehicle was not in use. The 1991 pickup accumulated approximately 48,000 kilometers (km) and the 1992 pickup approximately 32,000 km. Fueling these pickups with soydiesel increased engine power by 3 percent (1991 engine) and reduced power by 6 percent (1992 engine). Engine oil analysis indicated that the engines were wearing at a normal rate. Visible exhaust smoke was reduced as much as 86 percent when the diesel engine was fueled with 100 percent soydiesel. Transient emissions tests were done in an EPA certified laboratory. Carbon monoxide emissions were reduced by one percent, hydrocarbon emissions were reduced by 48 percent, and particulate matter emissions were increased by 13 percent when the engine was fueled with soydiesel.

Holmberg and Peeples (1994) summarized the work done for the National SoyDiesel Development Board. Biodiesel has accumulated nearly eight million miles in demonstrations involving more than 1,500 vehicles in fleets across the country, particularly in urban buses. Biodiesel has been used successfully as a motor fuel in many types of equipment from watercraft to locomotives. The results of numerous studies and demonstrations show the performance of Biodiesel to be substantially similar to, if not better than, diesel. They predict that as a renewable fuel with a very positive energy balance, Biodiesel will be a major contributor to the stabilization of greenhouse emissions. They also report that by using state-of-the art engine technology, Biodiesel reduced EPA-regulated emissions of PM, CO, THC, and NOx. Actual emissions tests do not verify their optimism that Biodiesel will reduce both NOx and PM.

Pischinger et al. (1982) reports on tests with the Volkswagen 1.6 liter diesel indirect injection engine installed in a VW Passat passenger car or a delivery van. In Volkswagen's rigid durability test program for diesel engines, the diesel engine was fueled with 100 percent methyl ester of soybean oil (MESO.) It was dynamometer tested for 1,418 hours operating about 70 percent of the time at maximum power and 20 percent at maximum torque. Values of torque, power, smoke levels, and cylinder compression remained within the normal variations expected for this test. Engine wear of the bearings, piston rings, cylinder bores, and valve train remained within the VW specifications. Differences in emissions and fuel consumption of the Passat diesel when comparing diesel fuel and MESO fuel were measured on a chassis dynamometer. A city driving cycle and a warm engine were used in the test. They reported that CO was 40 percent less, NOx increased 2.7 percent, and fuel consumption was increased 6 percent compared to diesel fuel.

Mittelbach and Tritthart (1988) tested a Volkswagen diesel Rabbit powered by a 1.6 liter four cylinder, 4-stroke, direct injection engine with a 50/50 volume blend of methyl ester of used frying oil and diesel fuel. A total of 100 liters of ester fuel was consumed. They reported that "no changes in operation whatsoever could be observed. The smoke emissions were extremely low and only a faint smell of burnt fat was detected. No volumetric fuel consumption was observed. They reported that "in our test the fuel consumption was almost the same as when using diesel fuel." They stated "about a 10% power loss with ester fuel can be expected with unchanged fuel delivery of the injection pump. However, because particulate emissions are halved when using ester fuel, a higher fuel input for the ester fuel may be tolerated by the engine without excessive full load smoke. So the engine power may become comparable for both fuels without any deteriorating effects on emissions." In their vehicle testing, they reported that a diesel Volkswagen Passat had run 26,500 km, and a Volkswagen van 5,200 km with MESO. It was difficult to identify any difference between the MESO-fueled vehicles compared to identical diesel-fueled vehicles.

Shafer (1994), from Mercedes-Benz Germany, reports on the use of methyl esters of soybean oil, rapeseed oil, and palm oil. The testing was performed in Germany and Malaysia in trucks, busses and industrial engines. Shafer concludes that if the fuel (RME and palm methyl ester [PME]) is of high quality, the fuel injection system can remain unchanged and no excess nozzle coking will be found: a too high glyceride content causes nozzle coking. The black smoke emission is reduced by at least 50 percent and the disagreeable odor can be reduced by installing an oxidation catalyst. He also states that engine oil dilution is within relatively tight limits and no sludge is apparent with a suitable lubricating oil.

Alfuso et al. (1993) reported on the characterization of the behavior of methyl ester of rapeseed oil in direct injection diesel engines at Istituto Motor of CNR. Regulated and unregulated emissions were monitored using transient and steady-state conditions with varied injection timing, with and without a catalytic convertor and exhaust gas recirculation (EGR). Tests indicated that RME promotes a rise in NOx emissions and a decrease in HC and CO, as well as a large reduction of smoke. Particulate matter produced by RME in transient cycles is higher than that obtained with 2-D. Using the EGR, in the presence of an exhaust-oxidating catalyst, showed a reduction in NOx, HC, and CO emissions and low effects on particulate matter with RME.

Numerous feedstocks for Biodiesel exist, including rapeseed, tallow, soybean, canola, peanut, sunflower, cottonseed, safflower, coconut, palm, and used cooking oils with which methyl or ethyl esters may be produced. Biodiesel reduces the opacity of smoke by up to 80 percent, decreases power by 6 percent, and increases fuel consumption 4 percent, due to the heat content of Biodiesel being about 11 percent less than 2-D. It also decreases HC by as much as 50 percent, CO by as much as 40 percent, and increases NOx almost inversely to PM by as much as 10 percent. Injector coking is slightly greater for Biodiesel, with the carbon deposits being harder than diesel deposits.

Fuel properties suggested by ASTM D-975 were reported in most of the papers reviewed, but no ester-specific properties were reported such as percent ester of the fuel, percent glycerol, and alcohol content. The percent of fuel that is ester is one factor that determines the quality of the fuel. The percent of Biodiesel which is ester, along with the viscosity, determines the rate at which carbon deposits are formed in the engine combustion chamber (Peterson et al., 1994). Unmodified triglycerides caused polymerization in the piston ring lands of earlier studies.

MATERIALS AND METHODS

A 20% blend of biodiesel with 80% number two diesel fuel (2-D) was studied using a diesel powered pickup at the University of Idaho. During the past decade researchers at the University of Idaho have shown that methyl ester of rapeseed when used as fuel in diesel engines is comparable to 2-D. This study was to verify the use of blends of Biodiesel in on-road vehicles.

TEST VEHICLE - The vehicle used for this test was a Dodge 2500, 3/4 ton pickup powered by a Cummins 5.9 liter turbocharged, intercooled, direct injected, diesel engine (ESN 5610101504, CPL-1579.) The engine was an inline six cylinder and had a bore and stroke of 102.0 x 120.0 mm respectively. It had a compression ratio of 15.1:1, and was rated at 119 kW at 2,500 RPM; with a peak torque or 542 N-m at 1,750 RPM. It was equipped with a Bosch VE distributor type fuel injection pump. This pickup was to operate on a nominal blend of 20% rape methyl ester (20RME), and 80% number 2 Diesel.

CHECK VEHICLES - Two similar pickups (three for a short time) were used as check vehicles. They were also equipped with 5.9 liter direct injection These vehicles were privately owned and were operated on 100 percent diesel fuel to serve as a comparison. Oil samples and analyses were performed at each owner's discretion and analyzed by the same laboratory as the Biodiesel pickups. It was intended to dynamometer test these vehicles but it turned out to be impractical because of the private ownership and because the vehicles automatic transmissions were not compatible with the dynamometer.

FUEL MIXING SYSTEM - The fuel delivery systems in the Biodiesel pickup was modified to provide for on-board mixing of the fuel. On-board mixing greatly extended the range of the vehicle compared to the original equipment. A 210 L (55 gal) insulated fuel tank was added to the bed of the vehicle to store the Biodiesel fuel. A 5.7 L (1.5 gal) mixing chamber, Figure 1, was mounted to the frame of each vehicle with the diesel and Biodiesel fuel lines routed to this chamber. Each fuel supply was transferred from the tanks to the combining chamber with 12-volt electric fuel pumps. The combining chamber was constructed from mild steel and designed to incorporate four floats. The bottom float was a normally-open, polypropylene float and stem mounted horizontally in the chamber 44 mm (1.73 in) from the bottom. This float operated a low fuel warning light in the operator's cab, which warned the operator that the fueling circuit was not functioning. The second float was also a normally open polypropylene float and stem mounted horizontally in the chamber. When the fuel dropped below this float a relay activated the diesel fuel pump. Diesel fuel was then transferred into the chamber until deactivated by a third float. The third float simultaneously activated the Biodiesel fuel pump and filled the chamber until the 20/80 blend was obtained. A fourth float, made of Buna-N and a brass stem, was mounted vertically in the top of the tank and could be adjusted to give the correct blend. The adjustment was preset in the laboratory before being mounted in the frame of the vehicle. Based on a 20 percent blend of Biodiesel / 80 percent diesel and 7.5 km/L (18 mpg) fuel consumption, on-board mixing increased the travel distance from 965 km (600 miles) to 7,700 km (4,800 miles) before requiring a Biodiesel fill up.

During the first 32,000 km (19,800 miles) of operation, rust began to form in the Biodiesel tank and was transferred to the fuel filter. The fuel filter required replacing approximately every 4,800 km (3,000 miles) due to plugging and loss of engine power. The mild steel 210 L (55 gal) tank and combining chamber were replaced with stainless steel tanks of similar design. A new 12-volt positive displacement fuel pump was installed for the Biodiesel fuel and a 12-volt shut-off solenoid valve was placed in line with the pump. Also at this time, the operators of the truck, The Idaho Department of Water Rosources (IDWR) were instructed to change to a different diesel fuel supplier.

FUEL HEATING SYSTEM - During cold weather operation the biodiesel fuels required heating to remain above their pour point, which were higher than normal diesel fuel. Engine coolant was used to warm the fuel in the Biodiesel fuel tanks. A stainless steel in-line fuel warmer was installed horizontally into the 210 liter (55 gal) biodiesel fuel tank. A thermostat with an adjustable set point was set at 13°C and closed on rise to operate the coolant pump. The coolant lines were 15.9 mm (.625 in) silicon heater hose, which was routed alongside the fuel supply and return lines and laid beside the fuel combining chamber and Biodiesel fuel pump. They were insulated to help keep the fuel lines and the fuel in the combining chamber above the pour point when the vehicle was not in operation.

In cold weather, when the pickup is not used and the engine is not running, a 110 volt thermostatically controlled engine pre-heater was used to keep the engine coolant at 38°C. The thermostat was installed on the inlet side of the heater. It sensed the temperature of the coolant at the inlet to the heater and kept the coolant at the preset temperature range.

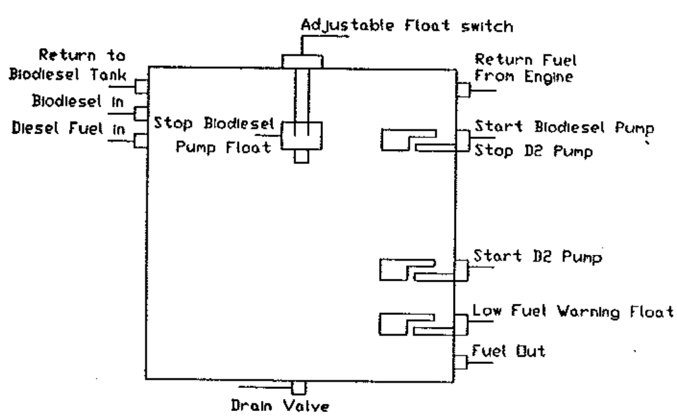

Figure 1: Fuel Combining Chamber.

Since the coolant pump operates on 12-volts, a 10 amp DC power supply was used to convert standard 120-volt AC power into regulated 12-volt DC power. A 12-volt, 25 amp DC power relay was used to switch the power source when 120-volts AC was required. A shut off valve was added prior to the coolant pump for flow-control purposes.

OTHER MODIFICATIONS - While the engine of the test vehicle was unmodified, the vehicle was modified for convenience of running the test. For example, it is known that esters will deteriorate rubber components over a period of time, so the rubber fuel lines were replaced with

Viton hose. A low coolant indicator was installed and a red light in the cab was used to warn the operator of low coolant. An hour meter, operated by engine oil pressure, was also added. A Biodiesel fuel-tank gauge gave an indication of the fuel level in the Biodiesel tank. Additional ammeters and indicator lights indicated whether the fuel mixing system was working properly. Each pickup was equipped with a log book to keep daily and long-term records. Also, a maintenance record book was kept for each vehicle, which included the oil samples, dynamometer test data sheets, and any other scheduled or unscheduled maintenance.

FUELS - The feedstock for the fuel in this study is winter rapeseed, Dwarf Essex variety, expelled at the University of Idaho Department of Agricultural Engineering Farm Scale Processing Facility. The blend of fuel was a 20 percent blend of rapeseed methyl ester (RME), produced at the farm scale processing facility, and 80 percent 2-D. The RME was processed using equipment and techniques scaled up and modified from prior research at the University of Idaho (Peterson et al., 1997.) The abbreviations used to denote the different fuels are as follows:

RME	100 percent methyl ester of rapeseed
20RME	20 percent RME and 80 percent 2-D
2-D	100 percent number two diesel fuel

The fuels were characterized by evaluating the parameters required in ASAE EP X552. The tests for specific gravity, viscosity, cloud point, pour point, flash point, heat of combustion, total acid value, catalyst, and fatty acid composition were performed at the Analytical Lab, Department of Biological and Agricultural Engineering, University of Idaho. The boiling point, water and sediment, carbon residue, ash, sulfur, cetane number, copper corrosion, Karl Fischer water, particulate matter, iodine number, and the elemental analysis were performed at Phoenix Chemical Labs, Chicago Illinois. The HPLC and titration analysis for total and free glycerol, percent of oil esterified, free fatty acids, and mono-, di-, and triglycerides were performed by Diversified Labs Inc., Chantilly, Virginia.

Transesterification of vegetable oils involves reacting an alcohol with the oil in the presence of an alkaline or acidic catalyst. With methanol, a methyl ester and glycerol are produced. Hoffman (1989) gave the following description of the transesterification process, " An ester is the condensation product of an acid and an alcohol. Transesterification may be either an acidolysis, where the acid component of an ester is replaced by another acid, or an alcoholysis, where the alcohol component of an ester is replaced with a different alcohol." Vegetable oils are esters of fatty acids and glycerol. In this work, the transesterification being studied is an alcoholysis where the glycerine component of a vegetable oil is replaced by an alcohol, Fig. 2.

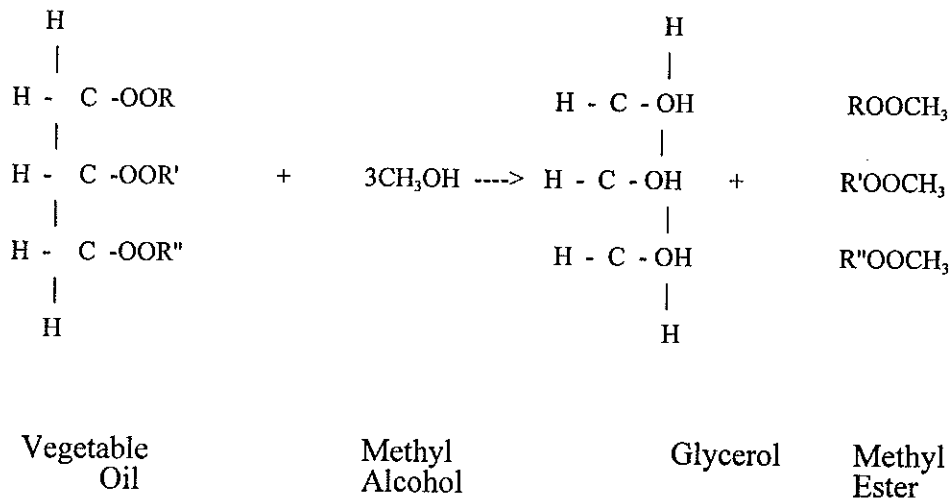

Figure 2. Vegetable Oil Transesterification

OIL EXTRACTION AND PROCESSING - All of the oil used in these studies has been extracted with a small oil extraction plant consisting of two mechanical screwpresses manufactured by CeCoCo of Japan. The plant has a capacity of 45 kg per hour (100 lb per hour) for each press and thus can generates about 38 liters (10 gallons) of oil per hour at full capacity. For a complete description of the process see Peterson et al. (1983c) and Peterson et al. (1989).

The biodiesel plant consists of two transesterification reactors one of 750 L capacity and one of 1000 L capacity. The 750 L reactor consists of a conical bottomed, cross-linked polyethylene tank purchased from Pasco Poly-Tank, Inc., Pasco, Washington; an R. S. Corcoran model 2000D* explosion proof centrifugal pump (75-95 L per min capacity) (R. S. Corcoran Co., New Lenox, IL) compatible with methanol, vegetable oil, KOH solutions, fluid viscosities from 0.65-55.0 centistokes, and explosion proof; a 0.2 kW (1/4-hp) lab mixer with a 3.4:1 gear reduction unit (1725 motor rpm and 514 r/min rotor speed). The 1000 L reactor is of stainless steel and otherwise uses the same mixer and pump. The biodiesel plant produced over 28,000 L of fuel in 1995 and 19,000 L in 1996. Typically 605 L (160 gal) or 950 L (250 gal) batches have been produced. The mixer should have an explosion proof motor. A 0.75 kW (1 horsepower) portable gear pump with totalizing meter is used to transfer the raw vegetable oil and the finished ester to the bulk storage tanks. Additional equipment includes a low speed hydraulic motor and mixer for use in mild stirring during the water wash operation.

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*Mention of trade names is for convenience in description and does not imply an endorsement of the product mentioned nor discrimination of similar products not mentioned.

The polymer tank and system pump are mounted on a 1.2 m (4-ft.) by 2.4 m (8-ft.) steel platform with caster wheels and fork lift eyes. PVC pipe and fittings are used for all plumbing components. All of the reaction, settling, washing and separating takes place in the reactor tank. The methanol and KOH are mixed in a smaller 190 L (50 gallon) tank prior to being transferred to the large tank.

The methyl ester process utilizes 100 percent molar excess alcohol (preferably absolute or 100 percent pure), or a molar ratio of 6:1 alcohol to oil ratio. Based on the amount of input oil by weight, 1.1 percent of potassium hydroxide (KOH) is used. The following equations were used for the quantities processed:

$$MeOH = 0.225 \times Oil \qquad KOH = Oil/100$$

where ; Oil = desired amount of oil, in liters
MeOH = amount of methanol needed, in liters
KOH = amount of potassium hydroxide required, in kg

Example: <u>756 L (200 gal) batch</u>:

756 L (200 gal) raw, filtered rape oil
170 L (45 gal) methanol
7.30 kg (16.10 lb) KOH

The following transesterification procedure has been used for both methyl and ethyl ester production. The catalyst is dissolved into the alcohol by vigorous stirring in a small reactor. Because pure methanol is very flammable and its flame is colorless when ignited, explosion proof equipment and care in handling is essential. The oil is transferred into the Biodiesel reactor and then the catalyst/alcohol mixture is pumped into the oil and the final mixture stirred vigorously for two hours. A successful reaction produces two liquid phases: ester and crude glycerol. Crude glycerol, the heavier liquid will collect at the bottom after several hours of settling. Phase separation can be observed within 10 minutes and can be complete within two hours after stirring has stopped. Complete settling can take as long as 20 hours. After settling is complete, water is added at the rate of 5.5 percent by volume of the oil and then stirred for 5 minutes and the glycerol allowed to settle again. After settling is complete the glycerol is drained and the ester layer remains. Washing the ester is a two step process which is carried out with extreme care. A water wash solution at the rate of 28 percent by volume of oil and 1 gram of tannic acid per liter of water is added to the ester and gently agitated. Air is carefully introduced into the aqueous layer while simultaneously stirring very gently. This process is continued until the ester layer becomes clear. After settling, the aqueous solution is drained and water alone is added at 28 percent by volume of oil for the final washing.

The process described has been used successfully to produce RME. Conversion has been 98 percent and above. All of the problems encountered have been mechanical in nature (leaks, failure to prime the pump, etc.) Handling large quantities of methanol constitutes a health, explosion, and fire hazard and is the biggest major element of concern in implementing the process. The water used constitutes a disposal problem, however, over the course of this project improvements have been made to reduce the amount. Water used has gone from nearly 10 L/L (10 gal/gal) of fuel produced to less than ½ L/L (1/2 gal/gal) of fuel produced. No attempt has been made to define the process for any purpose other than for fuel use. Transesterification is used only as a method to lower the viscosity of the vegetable oil to a more suitable level for use as a fuel. The washing process is used to remove the excess alcohol, glycerine and KOH from the fuel.

GLYCERIN, EXCESS ALCOHOL AND KOH - Glycerin recovery has not been a part of this project. At the present time the glycerin is sold to an outside company. Methods to recover the methanol and purification of the glycerin could improve the economics and reduce the cost of the fuel in a large scale plant. In our situation the extra investment required has not been thought to be justified for the small amount of fuel produced each year.

DIESEL FUEL - While the RME was produced by the Biological and Agricultural Engineering Department at the University of Idaho, the diesel was purchased at convenient filling stations. Phillip's low sulphur diesel reference fuel was used for the diesel fuel in the emissions tests.

DYNAMOMETER TESTING - The vehicle had a break-in period and was dynamometer tested before the Biodiesel fuel mixing system was incorporated. The pickup was dynamometer tested approximately every 16,000-24,000 km (10,000 - 15,000 miles) at Western States Caterpillar in Spokane, Washington. During each dynamometer test, the vehicle was tested with the following: once with the 20/80 mix and again with 100 percent diesel and once with 100 percent RME. A full rack torque test was performed with a predetermined set of engine RPM's programmed into the computer to obtain repetitive data. The vehicle was dynamometer tested from 1,600 to 2,650 RPM in 150 RPM increments. A computer recorded vehicle power, vehicle speed, fuel economy, engine RPM, opacity, torque, engine oil pressure, fuel pressure and temperature, exhaust temperature, inlet air temperature, and coolant temperature. Intake manifold pressure and engine blowby were also measured.

PERFORMANCE PARAMETERS - After each dynamometer test the injectors were removed from the engine to check for carbon deposits using the procedure described in "A Rapid Engine Test to Measure Injector Fouling in Diesel Engines Using Vegetable Oil Fuels" (Korus et al., 1985.) The cylinder compression was tested and the injector valve opening pressure was also checked. The Cummins engine, has direct access to the combustion chamber and cylinder walls through the injector bore in the cylinder head. A fiberoptic borescope was used to visually inspect the amount of carbon build up on the piston crown and valve heads and to check for any abnormal cylinder wear.

Oil samples were taken at each oil change, which was approximately at each 4,800 km (3000 miles) for the Biodiesel pickup, and at the convenience of the owners of the control vehicles. The oil samples were analyzed at a commercial oil analysis laboratory for wear metals, and physical tests were performed, including antifreeze, fuel dilution, water, and viscosity. An infrared analysis for soot, sulfur, nitration, and oxidation of the engine oil was also conducted. The reportable limits for each metal were supplied by the oil analysis lab. Two laboratories were used over the course of the four years of testing (Western States Cat, Boise, ID and Chevron LubeWatch, Spokane, WA.)

The emissions tests were not performed on the test vehicle described in this report but were conducted with a 1994 Dodge with a 5.9L Cummins diesel engine. The same test fuels were included as part of that test and are included here for completness since they were conducted during the time frame of the present tests. The emissions tests were conducted at the Los Angeles Metropolitan Transit Authority (LA-MTA) Emissions Testing Facility (ETF) in Los Angeles, California. This facility has instrumentation to measure all regulated emissions: total hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), and particulate matter (PM). Peterson and Reece (1994) and Peterson and Reece (1996) provided a complete report on these tests including materials and methods, procedures, and results from both methyl and ethyl esters of rapeseed oil.

Two test cycles were utilized for this program. The first was a modified arterial cycle (arterial). The standard form of this test was doubled, creating a 758 second, eight event cycle. The arterial cycle, as used, had eight repetitions of acceleration to 64 km/h (40 mph) and decelerating to 0 km/h (0 mph). The second cycle was the EPA Dynamometer Driving Schedule for Heavy-Duty Vehicles (Code of Federal Regulations, 1993.) The EPA cycle took a total of 1060 seconds.

RESULTS AND DISCUSSION

FUELS - A complete summary of the fuel characterization data is listed in Table 1 for each fuel used in this study. Important observations on a few of the parameters are listed below.

Viscosity - RME had a viscosity 1.8 times greater than 2-D. The 20RME had a viscosity very similar to 2-D.

Cloud and Pour Point - The pour point for 2-D was -23°C and -15°C to -17°C for Biodiesel and blends. RME had a cloud point of 0°C and 2-D was -12°C, the blends were within 1°C of 2-D.

Sulfur - 2-D (not low sulfur diesel) had 18 times more sulfur than RME.

Heat of Combustion - The gross heat of combustion for 2-D is 5.6 percent greater than RME fuel.

Flash Point - A flash point of 74°C was measured for 2-D while the RME was measured at 179°C. The higher flash points of Biodiesel indicate that it is safer to use, store, and handle based on fire safety concerns.

Table 1. Fuel Characterization Data

	RME	20RME	2-D
Fuel Specific Properties			
Specific Gravity, 60/60	0.8802	0.854	0.8495
Viscosity, CS @ 40°C	5.65	3.1	2.98
Cloud Point, °C	0	-12	-12
Pour Point, °C	-15	-15	-23
Flash Point, °C	179	82	74
Boiling Point, °C	347	194	191
Water and Sediment, % Vol.	<0.005	<0.005	<0.005
Carbon Residue, % mass	0.08	0.06	0.16
Ash, % mass	0.002	0.00	0.002
Sulfur, Wt%	0.012	0.035	0.036
Cetane Number	61.8	51.4	49.2
Heat of Combustion, Gross, MJ/kg	42.88	44.54	45.4
Copper Corrosion	1A	1A	1A
Karl Fischer Water, ppm	847	153	38
Particulate Matter, mg/L			
Total	1.1	1.1	0.9
Non-Combustible	<0.1	<0.1	<0.1
Elemental Analysis			
Nitrogen, ppm	10		
Carbon, %	81.5	84.76	86.67
Hydrogen, %	11.72	12.89	12.98
Oxygen, % (by difference)	6.76	2.35	0.33
Iodine Number	97.4	24.5	8.6
Ester Specific Properties			
Percent Esterified	98.02		
Acid Value	0.128		
Free Glycerol, %wt	0.4		
Total Glycerol, %wt	0.86		
Free Fatty Acids, %wt	0.57		
Monoglycerides, %wt	0		
Diglycerides, %wt	1.35		
Triglycerides, %wt	0.45		
Alcohol Content, % mass	<1.0		
Catalyst, microgram/gram	11		
Fatty Acid Composition, %			
Palmitic (16:0)	2.2		
Stearic (18:0)	0.9		
Oleic (18:1)	12.6		
Linoleic (18:3)	12.1		
Linolenic (18:3)	8		
Eicosenoic (20:1)	7.4		
Behinic (22:0)	0.7		
Erucic (22:1)	49.8		

ON-ROAD VEHICLE - The addition of the fuel tanks and heating system added approximately 230 kg (507 lbs) to the total mass of the vehicle, with the Biodiesel tank filled to capacity. There was no noticeable change in power, acceleration or fuel economy with the added mass. The total vehicle test was 163,807 km (101,785 miles). The engine was switched from diesel to 20RME and the first dynamometer test was completed at 3180 km (1637 miles.) Thus the 161,000 km (100,000 mile) test on 20RME officially began at 3180 km (1637 miles.) Over the duration of the test, the vehicle averaged 8.7 km/L (20.9 mpg) using an average mixture of 27.9% RME. The pickup used 12,795 L (3,380 Gal) of diesel, and 4,959 L (1310 Gal) of RME for a final total blend of 28.0 percent. The fuel economy for the first 3,180 km (1,976 miles) using 100 percent 2-D was 8.55 km/L (20.6 mpg.)

Rust was observed in the steel tanks at 48,280 km (30,000 miles) and continued to be a problem until the tanks were converted to stainless steel. The rust may have been due to the heating and cooling of the fuel in the tank during the winter, condensing the moisture in the atmospheric air, and/or a very small amount of catalyst in the RME fuel, which is basic and would speed up the oxidation reaction. After converting to stainless steel tanks there was still unusual fuel filter plugging during the winter months. A wax-like substance in the fuel filter was analyzed and it was determined to be 50 percent diesel fuel and 50 percent Biodiesel.

FUEL HEATING SYSTEM - The fuel heating system worked very well through the course of testing. After the initial installation of the heating system, the pickups were parked outside over a period of three days and nights with temperatures below -9°C (15.8 °F.) The ambient and Biodiesel fuel temperatures were monitored with thermocouples and a data acquisition system for the three day period. As the ambient temperature dropped below -9°C, the Biodiesel fuel maintained a temperature of 12.7°C (54.9 °F) to 15.5°C (59.9 °F.)

DYNAMOMETER TESTING - Figure 3 is a graphical comparison of the power and smoke density with each of the three fuels tested over a period of seven dynamometer tests. Dynamometer tests were done at 1475 miles, 10,500 miles, 20,033 miles, 32,628 miles, 49,200 miles, 75,737 mile and at the conclusion of the test at 101,785 miles. On the average, 100 percent RME produced 4.96 percent less power than 2-D and 20RME produced 1.47 percent less than 2-D. Also, smoke density was reduced 32 percent with 100 percent RME, while 20RME increased smoke density by 83 percent over 2-D.

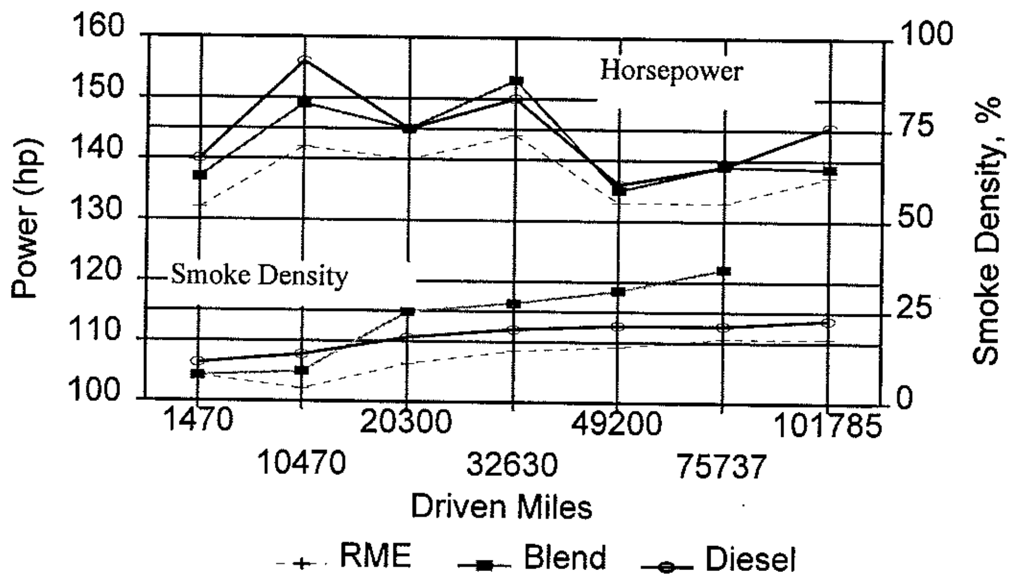

Figure 2. Power and Smoke Density for each of the dynamometer tests.

__Check Vehicles__ - The Dodge check pickups were equipped with automatic transmissions, which are not compatible with the dynamometer.

ENGINE OIL ANALYSIS - Chevron Delo Multigrade SAE 15W-40 heavy duty engine oil was used. Wear data for the Dodge pickup was at acceptable levels without any significant differences between the sampling reports. The oil analysis reports are included as Appendix B for both the test vehicle and the check vehicles. Using aluminum and iron as comparison analysis the test vehicle averaged 2.2 ppm for aluminum and 8.0 ppm for iron, the first check vehicle averaged 2.4 ppm for aluminum and 8.5 ppm for iron, the second check vehicle averaged 5.4 ppm for aluminum and 20.0 ppm for iron, and a third check vehicle averaged 5.7 ppm for aluminum and 64 ppm for iron (the third of four samples showed iron at 183 ppm with the others at 20-28 ppm.) Check vehicle #1 was tested for 203,278 km (126,311 miles), #2 for 93,663 km (58,200 miles) and #3 for only 19,602 km (16,779 miles.)

PERFORMANCE PARAMETERS - Injector coking was measured after each dynamometer test, but a check vehicle operating on 100 percent 2-D was not studied during this testing; therefore, an injector coking index is not available. There was very little carbon buildup on the tip of the fuel injectors, either visually or by calculating the area of the coked injector from one interval to the next.

The fuel injectors were sticking when tested at the 79,300 km (49,275 m) engine performance test because of the fuel filter plugging and rusty fuel being introduced into the injectors. The injectors were cleaned and retested, which resulted in a good spray pattern and the specified valve opening pressure.

The engine cylinder compression was checked at each performance interval. The cylinder compression started at an average 3427 kPa (497 psi) with a standard deviation of 51.4 kPa (7.4 psi) and ended with exactly the same average of 3427 kPa (497 psi) with a standard deviation of 32.5 kPa (4.7 psi.)

The average beginning valve opening pressure (VOP) was 24,270 kPa (3520 psi) with a standard deviation of 149 kPa (21.6 psi). The average ending VOP was 24,304 kPa (3525 psi) with a standard deviation of 172 kPa (25 psi.)

The internal combustion areas were borescoped at each performance interval. There was no significant visual change from one time to the next. At the end of this study there were a few slight carbon scratches on the thrust side of the cylinder walls of each cylinder, which is normal for the number of accumulated miles. There did not appear to be any excess amount of carbon buildup on the piston crowns or the cylinder head and valves.

The drivers of the vehicles did not notice any change in vehicle operation or other abnormalities during the course of the test. The vehicle averaged 8.68 km/L (20.9 mpg) for the 157,310 km (97,748 miles) for which records are available, the fuel mixture averaged 28 percent and the vehicle had an average speed of 79.2 km/h (49.2 mph) based on the hour meter. One Dodge check vehicle averaged 7.06 km/L (17 mpg). The check vehicle was used for utility type applications with heavy loads while the test vehicle generally were operated empty, which may explain the differences in economy.

PERFORMANCE - The pickup was used to shuttle personnel around the northwestern United States, move lightweight scientific equipment to different research areas, and carry information to research areas. The pickup was seldom used for heavy hauling or towing during the test period. The test vehicle was driven mostly by IDWR staff (Table 5.) They recorded the operational observations as indicated in Table 4.

In addition to the dynamometer tests, the compression of each cylinder and the valve opening pressure of each injector was tested at regular intervals Table 1 shows the results of those tests.

Table 1
Cylinder Pressure and Valve Opening Pressure
At Each Dynamometer Test

	Mileage						
	1475	10500	20033	32628	49200	75737	101785
Cylinder	Cylinder Compression (psi)						
1	480	490	500	490	480	480	500
2	500	485	510	500	485	500	490
3	500	500	510	490	485	480	500
4	500	485	510	510	485	500	490
5	500	500	510	480	490	490	500
6	500	500	510	510	500	490	500
	Valve Opening Pressure (psi)						
1	3550	3425	3400	3450	3450	3550	3550
2	3510	3400	3400	3600	3450	3550	3500
3	3500	3400	3500	3600	3500	3400	3550
4	3500	3400	3500	3600	3500	3500	3550
5	3510	3350	3300	3300	3350	3300	3500
6	3550	3550	3350	3300	3350	3300	3500

Oil analysis - The oil was changed in the engine at approximately 4,800 km (3,000 mile) intervals and oil samples taken. No oil was added to except during the oil changes. The results of the oil analysis showed that there was no unusual deterioration of the engine, or any unusual change in used oil composition. Table 2 shows the breakdown of some of the data from the oil analysis. The complete analysis are shown in Appendix A.

Table 2
Partial Summary of Oil Analysis Reports

	km (miles)	Pb[#]	Cu[#]	Fe[#]	Al[#]	Na[#]	Cr[#]	Viscosity 40°C cSt	% allow-able soot	Wear Elements
	2636 (1638)	1	18	10	2	3			1	Normal
	7229 (4492)	2	5	10	2	9			14	Normal
	13,137 (8163)	1	2	7	1	8				Acceptable
	18,189 (11302)	3	1	8	2	9			9	Acceptable
	23,760 (14764)	1	18	7	1	10			1	Acceptable
	28,627 (17788)	1	9	5	1	17			1	Acceptable
	33,027 (20522)	1	21	5	1	17			1	Acceptable
	38,355 (23833)	2	18	5	7	19				Acceptable
	43,209 (26849)	2	4	5	2	6				Acceptable
	52,820 (32821)	1	1	8	2	4				Acceptable
	58,282 (36215)	1	1	6	2	17				Acceptable
	74,789 (46472)	1	6	4	2	3				Acceptable
*	79,370 (49318)	2	1	10	4	0	0	13.4		No Corrective action required
*	84,571 (52550)	2	1	7	3	0	0	13.31		"
*	109,172 (67836)	1	1	6	3	0	0	13.39	0.1	"
*	121,734 (75642)	1	1	7	2	0	0	13.36	0.1	"
*	126,982 (78903)	2	1	7	2	4	0	13.43	0.1	"
*	132,951 (82612)	1	1	7	2	4	1	13.22	0.2	"
*	137,499 (85438)	2	1	6	2	2	0	12.82	0.02	"
*	142,515 (88555)	2	1	6	1	3	0	13.7	0.02	"
*	147,876 (91886)	3	1	5	1	9	0	13.47	0.2	"
*	154,359 (95914)	12	3	35	5	4	2	14.88	0.6	"
*	164,052 (101,937)	2	1	8	1	6	0	14.07	0.1	"

* indicates oil samples tested at Chevron, all others were done at Western States Caterpillar."
# Wear metals are reported in parts per million

Problems - The major maintenance or mechanical problems with the pickup, taken from the vehicle log book, are listed in Table 3, along with the mileage accompanying them. It should be noted that the fuel filter problem was finally solved by changing the RME tank to one made of stainless steel and by switching diesel suppliers. Rust in the mild steel fuel tanks was a problem until they were replaced with stainless steel.

Table 3
Summary of Maintenance Related Comments
from the Vehicle Log Book

Date	Problem	km (Mileage)
9/16/92	Very little RME was being used--a plug was found in the valve	3,903 (2,425)
12/18/92	Changed fuel filter	17,033 (10,584)
3/12/93	Coolant level low	23,767 (14,768)
4/16/93	Strange loss of Power	27,597 (17,148)
5/12-13/93	Major Loss of Power--added injector cleaner and water desiccant	29,614 (18,401)
5/13/93	Changed fuel filter--solved power loss problem	29,675 (18,439)
7/13/93	Cruise control does not work properly	39,054 (24,267)
7/15/93	Diesel tank fuel gauge does not work	39,490 (24,538)
7/20/93	Upper float stuck, RME pump continues to run	39,519 (24,556)
7/30/96	Pickup appears to use a lot of RME	41,405 (25,728)
11/13/93	RME degrading gasket on fuel tank--pieces falling into tank	49,510 (30,764)
11/15/93	Pickup does not cold idle well with higher RME ratios	49,877 (30,992)
11/24/93	Engine stalled and would not restart--left outside previous night at -7 F	50,765 (31,544)
12/2/93	Engine would not start--replaced filter--had truck towed to Cat shop and bled fuel lines--appears to run fine now	50,791 (31,560)
2/8/94	Engine quit--fuel problems--replaced fuel filter, but no help--electrical problems--short in electrical system	56,939 (35,380)
3/18/94	Changed fuel filter--solved power loss problem	63,170 (39,252)
4/21/94	Changed fuel filter--solved power loss problem	66,910 (41,576)
6/7/94	Changed fuel filter--solved power loss problem	74,307 (46,172)
7/6/94	Changed fuel filter--solved power loss problem	78,101 (48,530)
10/11/94	Changed fuel filter--solved power loss problem	83,041 (51,599)
10/30/94	Changed fuel filter--solved power loss problem	85,577 (53,175)
12/5/94	Changed fuel filter--solved power loss problem	88,675 (55,100)
2/11/95	Changed fuel filter--solved power loss problem	92,534 (57,498)
5/1/95	Changed fuel filter--solved power loss problem	102,032 (63,400)
7/27/95	Changed fuel filter--solved power loss problem	112,364 (69,820)
11/19/96	Changed fuel filter--solved power loss problem	126,229 (78,435)

4/9/96	Cruise control is not operating properly	140,072 (87,037)

Destinations: - Table 4 gives a listing of the different places that the pickup visited along with the date and mileage. During the test period, the pickup visited seven western states, and one national park. It was in many of the towns and cities in Idaho, as well as many other large cities in other states.

Table 4
Summary of Vehicle Destinations

Date	Location		Km (Mileage)
19-Aug-92	Weiser	Idaho	3,418 (2,124)
20-Aug-92	Garden City	Idaho	3,421 (2,126)
26-Aug-92	Kimberly	Idaho	3,879 (2,410)
4-Sep-92	Eagle	Idaho	3,940 (2,448)
8-Sep-92	Portland	Oregon	4,606 (2,862)
10-Sep-92	Boise	Idaho	5,335 (3,315)
17-Sep-92	Murphy	Idaho	5,506 (3,421)
25-Sep-92	McCall	Idaho	6,016 (3,738)
30-Sep-92	Downey	Idaho	6,705 (4,166)
6-Oct-92	Rexburg	Idaho	7,760 (4,822)
7-Oct-92	Pocatello	Idaho	7,905 (4,912)
19-Oct-92	Seattle	Washington	8,740 (5,431)
30-Oct-92	Kamiah	Idaho	10,824 (6,726)
13-Nov-92	Mountain Home	Idaho	13,395 (8,323)
13-Nov-92	Fairfield	Idaho	13,494 (8,385)
18-Nov-92	Bliss	Idaho	14,239 (8,848)
20-Nov-92	Idaho City	Idaho	14,537 (9,033)
23-Nov-92	Troutdale	Oregon	15,265 (9,485)
7-Dec-92	Moscow	Idaho	16,666 (10,356)
18-Dec-92	Spokane	Washington	16,975 (10,548)
4-Jan-93	Lewiston	Idaho	17,119 (10,637)

5-Jan-93	Burley	Idaho	19,151 (11,900)
12-Jan-93	Twin Falls	Idaho	18,649 (11,588)
4-Feb-93	Caldwell	Idaho	19,827 (12,320)
16-Feb-93	Wells	Nevada	20,043 (12,454)
21-Feb-93	Butte	Montana	21,060 (13,086)
24-Apr-93	Pasco	Washington	28,530 (17,728)
5-May-93	Shoshone	Idaho	28,976 (18,005)
25-May-93	Potlatch	Idaho	31,265 (19,427)
31-May-93	Pullman	Washington	32,081 (19,934)
15-Jul-93	Wilder	Idaho	39,490 (24,538)
22-Jul-93	Middleton	Idaho	39,612 (24,614)
27-Aug-93	Steptoe	Washington	42,028 (26,115)
30-Aug-93	Orfino	Idaho	42,334 (26,305)
6-Oct-93	Idaho Falls	Idaho	45,063 (28,001)
19-Oct-93	Jerome	Idaho	47,487 (29,507)
28-Jan-94	Grandview	Idaho	55,624 (34,563)
9-Feb-94	Challis	Idaho	55,917 (34,745)
7-Feb-94	Arco	Idaho	56,688 (35,224)
11-Mar-94	Los Angeles	California	60,629 (37,673)
12-Mar-94	Bishop	California	61,564 (38,254)
19-Mar-94	Winnemucca	Nevada	63,685 (39,572)
25-Apr-94	Bend	Oregon	67,913 (42,199)
11-May-94	Horsehoe Bend	Idaho	70,138 (43,582)
13-May-94	Castleford	Idaho	70,803 (43,995)
8-Sep-94	Nampa	Idaho	81,394 (50,576)
5-Oct-94	Reno	Nevada	82,389 (51,194)
3-Jan-95	Payette	Idaho	89,146 (55,393)
11-Feb-95	Burns	Oregon	92,418 (57,426)
1-Mar-95	Rupert	Idaho	96,419 (59,912)

12-Apr-95	Sandpoint	Idaho	99,110 (61,584)
12-Jun-95	Mackay	Idaho	108,341 (67,320)
6-Jul-95	Emmett	Idaho	109,867 (68,268)
15-Jul-95	Wendell	Idaho	110,493 (68,657)
20-Jul-95	Blackfoot	Idaho	111.,080 (69,022)
16-Aug-95	Melba	Idaho	114,757 (71,307)
18-Sep-95	Tuttle	Idaho	117,621 (73,086)
14-Sep-95	Cody	Wyoming	118,782 (73,808)
17-Nov-95	Couer D' Alene	Idaho	126,020 (78,305)
29-Nov-95	Kennewick	Washington	127,891 (79,468)
12-Dec-95	Hagerman	Idaho	128,814 (80,041)
5-Jan-96	Ellensburg	Washington	129,646 (80,558)
21-Feb-96	Ashton	Idaho	134,548 (83,604)
20-Apr-96	Riggins	Idaho	141,675 (88,033)
16-May-96	Preston	Idaho	144,252 (89,634)
19-May-96	Malta	Idaho	144,950 (90,068)
20-May-96	West Yellowstone	Montana	145,613 (90,480)
24-May-96	Ontario	Oregon	146,677 (91,141)
12-Jun-96	Gooding	Idaho	147,828 (91,856)
20-Jun-96	Ketchum	Idaho	148,530 (92,292)
3-Jul-96	Aberdeen	Idaho	149,437 (92,856)

EMISSIONS TESTS

Testing for the emissions tests was conducted with a 1994 pickup with a 5.9 L Cummins engine nearly identical to the engine in the 1992 project vehicle. The 1994 engine has an inline injector pump rather than a rotary pump as in the 1992 vehicle. Since a large amount of data were collected, only summary data from emissions testing is reported in this paper. Modal data were archived every one second during the test. The data presented includes fuel type, cycle, HC, CO, NOx, CO_2, and PM. All the regulated emissions were higher for the EPA cycle than for the modified arterial cycle. This is probably due to the increased idling time and non-repetitive nature of the EPA cycle. The 100RME showed a slight reduction in NOx, a significant reduction in HC and CO, and a slight increase in PM and CO_2 compared to 1002-D. Table 1 shows the absolute value of emissions measured and Tables 3 and 4 show the percent change in emissions compared to diesel control fuel for RME and blends of RME for the arterial and EPA cycles.

Table 3
1994 Emissions Data, EPA Cycle
(no catalytic converter)
(gm/mile)

	HC	CO	NOx	CO_2	PM
Diesel	1.254a*	4.497a	6.850a	698.580a	0.411a
20RME	1.002b	3.07b	6.600b	709.13a	0.353a
100RME	.650d	2.08c	6.313c	703.89a	0.510a

*Numbers in the same column followed by the same letter of the alphabet are not significantly different according to Fischer's protected LSD comparison.

Table 2: Arterial Cycle Summary

	Emissions Percent Increase (+) or Decrease (-) Compared to Diesel Control Fuel		
Volume Percent of RME in Diesel Control Fuel	20% RME	50% RME	100% RME
HC	-20.2*	-37.2*	-55.6*
CO	-25.3*	-39.1*	-42.2*
NOx	-2.6*	-5.3*	-9.1*
CO_2	0	+0.7	+0.7
PM	-10.4	+7.6	+6.8

* Numbers followed by a * are significantly different from diesel (P<=0.05)

Table 3: EPA Cycle Summary

	Emissions Percent Increase (+) or Decrease (-) Compared to Diesel Control Fuel		
Volume Percent of RME in Diesel Control Fuel	20% RME	50% RME	100% RME
HC	-18.0*	NA[1]	-49.5*
CO	-31.3*	NA	-54.0*
NOx	-4.1*	NA	-7.6*
CO_2	+1.6	NA	+0.7
PM	-7.6	NA	+21.2*

*Numbers followed by a * are significantly different from diesel (P<=0.05)
[1]NA - not available, data was not taken for the 50% RME blend.

161,000 km (100,000 m) Engine Tear Down

When the vehicle reached 161,000 km (100,000 miles) the diesel engine was removed from the truck and shipped to Cummins Engine Company in Columbus, Indiana for analysis. Charles Peterson from the University of Idaho and Craig Chase representing the Pacific Northwest and Alaska Regional Bioenergy Program inspected the engine at the tear down. The condition of the engine obviously reflected the light load condition of use in the pickup. However, it was generally considered to be in a condition which could be characterized as good or better than that which would have been expected with diesel fuel. Engine parts were clean and showed little wear. The detailed description of the engine provided by the Cummins engineers indicated that everything was in good order with the exception of the water pump bearing, a condition not caused by the fuel; the crankshaft seals, which showed some tendency to harden with a resulting slight depression where they make contact with the shaft; rusting of the fuel filter attachment stud;and considerable varnish within the injector pump. Engine inspectors did not think that the varnish was affecting the performance of the pump and that the amount of varnish was probably increased because of the considerable rust exhibited in the mild steel tanks used in the early part of the test.

The following report was provided by Cummins Engine Company on 23 Dec 1996 by James Branner, Jr., Technical Specialist, as their report of the "U of Idaho B5.9 Engine Teardown".

> Cummins would like to provide the following summary of the visual observations of the B5.9 liter engine teardown and inspection at the Mid-Range Engine Technical Center (METC) after running 102,000 miles in a 1992 Dodge Ram truck on 20% rape methyl ester and 80% #2 diesel fuel.
>
> Engine S/N 56101504 was run on Chevron 15W40 engine oil. The engine was built as a 160 hp @ 2500 rpm 1991 automotive rating. The engine did not have any special parts. The duty cycle for this engine was very lightly loaded as compared to typical duty cycles

for the B5.9 engines' applications. The truck was used to shuttle personnel and move light-weight scientific equipment.

In general, this engine was in a very similar condition as to the previous biodiesel engine Cummins inspected that operated on 100% soybean-based methyl ester. Overall, the engine was in good condition for this lightly loaded duty cycle. The only leak observed was a slight seep at the front crank seal which had collected some dust and was not fuel system related.

FUEL SYSTEM:
Although no particular fuel system problems were noted or discussed during teardown, it could be seen from data supplied by the University of Idaho that the engine lost about 10 hp** during its last chassis dynomometer test. It is unknown what caused this power loss, though power was still very close to the low side of the specification. There are a great many factors that could have led to this problem. It is also noted in the log sheets that there were vehicle performance problems throughout the demonstration. RME tank contamination is assumed to have led to earlier than expected fuel filter contamination to lead to these performance problems.

The fuel pump was run on the pump stand at METC with standard bench test nozzles and found to be in good condition. All fueling was slightly below specification though still within the +/- tolerance with the exception of the idle flow rate which was low. The low flow rate may have been the result of removing the top cover off the pump prior to the stand test. Note, that there were no reported field problems of low engine idle speed. Idle fuel rate was adjusted back to specification before the pump was removed from the stand.

When the top cover was removed from the pump, a large amount of varnishing could be seen on the components inside the pump. Though the pump was still in working order, it is impossible to say what effect the deposits had or will have on the pump and/or engine performance and durability. The pump was not fully dis-assembled and no pre-/post-measurements were recorded.

All the injectors were pop tested at the METC pump lab to check for nozzle opening pressure and spray quality. All injectors were within specification and spray quality was considered good.

OVER HEAD COMPONENTS:
In general, the overhead was in very good condition. The valve lash measured during tear down were as follows:

Cylinder Number	Intake Valve Lash	Exhaust Valve Lash
1	0.012"	0.023"
2	0.011"	0.023"
3	0.010"	0.022"
4	0.010"	0.021"
5	0.011"	0.020"
6	0.012"	0.019"

(Lash specification: Intake = 0.01 +/- 0.002"; Exhaust = 0.02 +/- 0.002")

**The 10 horsepower drop in power mentioned must be considering the high horsepower compared to the ending horsepower since the ending and initial horsepower as shown on Figure 2 are nearly identical. The horsepower variations are within the expected tolerance of the dynamometer considering they were done under widely varying conditions over a period of 4 years. - Author

The log book does not mention whether or not the valve lash was adjusted during any maintenance intervals. Judging from the condition of the parts, it is likely that the over head was never adjusted. Only a few exhaust valves were slightly out of specification which is considered good.

POWER CYLINDER COMPONENTS:
In general, the power cylinder components were in good condition. Piston deposits were very similar to the previous biodiesel engine. Heavy carbon deposits were found in the areas above the top ring (balcony). No deposits were found below the balcony and the top ring groove was clean. All that could be seen in the top ring groove was a light staining color likely causedby slight fuel and/or oil deposits (varnishing).

Some unusual carbon deposits were found on some of the tips of the pistons' bowls. These unusual deposits were later explained to be due to thin injector shims (0.75mm instead of 1.5mm). These deposits were most likely formed by fuel spray contacting the piston during injection. No cracks were found in the pistons and wear was light in the grooves, skirt and pin bores (all considered normal for this application).

All the piston rings looked to be in good condition. The only problems found were some slight ring manufacturing flaws in the #5 and #6 2nd ring and #6 top ring. In the case of the 2nd rings, small areas of the scraping edge of the ring face were found chipped. In the case of the #6 top ring, there was a small twist at the end gap. None of these problems should have degraded engine performance. Oil consumption appeared to be normal based on reports.

Top ring face contact was around 50%. Side contact was normal with no pitting or chipping found. The 2nd rings had around 25% face contact. Side contact was normal with no pitting found. The oil rings looked to be in very good condition, though there was an unusual deposit found between the rails. These deposits are not viewed as an issue at this time.

The cylinder bores were in very good condition. There was some top and 2nd ring polished areas which are considered normal. Plenty of honing cross- hatching was still visible in all areas of the bore. No other signs of polishing were seen in the bores. The bores were relatively free from dirt scratches.

BOTTOM END COMPONENTS:
All the bottom end components were in good condition. Bearings had many hours of life left in them. Some light dirt scratching was found in the bearings which is not considered any problem. The crank shaft had some wear around the areas where the front and rear dust seal rub. The problem was not enough to cause leaks but was a little higher than what is usually seen.

CONCLUSIONS

At the conclusion of 161,000 km (100,000) miles on a blend of 20% RME and 80% diesel there was no indication of abnormal wear or performance. The on-board mixing system, designed and reported on in this paper, was essential only for this experiment. It should be clear, however, that for commercial use the blending would take place at the fuel plant, eliminating the on-board mixing system.

Emission tests show that a 20 percent blend of RME and 80 percent diesel produced a reduction in three of the four regulated emissions (CO_2 is not regulated) Pm being the exception. Specific conclusions from the results of this testing are presented below.

- Fuel characterization data show some similarities and differences between RME and 2-D. a) Specific weight is higher for RME, viscosity is 1.8 times that of 2-D at 40°C, and the heat of combustion is 5.6% lower than 2-D. b) Sulfur content for RME is 67% less than 2-D.

- Visually, all injector coking was low with 20RME. The injectors were cleaned at 79,340 km (49,300) due to rust.

- The fuel heating systems performed acceptably during the test period. The fuel combining systems were updated twice, due to continual adjustments, to achieve the targeted 20 percent blend. The over-all average blend for the test was 27.9 percent RME.

- On the average, RME produced 5 percent less power than 2-D and 20RME produced one percent less power than 2-D.

- On the average, smoke density was reduced 32 percent with 100RME, while 20RME increased smoke density 6.6 percent over 2-D.

- The results of the oil analysis showed that there was no unusual deterioration of the engine, or any unusual change in used oil composition from using the biodiesel fuel.

- Engine compression and injector valve opening pressure remained constant throughout the test.

- The average fuel consumption for RME was 4 percent higher than that of 2-D and 1.8 percent higher for 20RME. The differences in fuel consumption and power reflect the differences in heat of combustion and density between the two fuels.

- Emissions tests, averaged for both cycles, showed decreases in HC (52.6 percent), CO (48 percent), NOx (8.4 percent) and an increase in CO_2 (0.7 percent) and PM (14%) when 100RME is compared to 2-D.

- The 20RME fuel, avceraged for both arterial and EPA cycles, decreased HC(19 percent), CO (28 percent), NOx (3.4 percent), PM (9 percent), and there was an increase in CO_2 (0.8%) compared to 2-D.

- Statistical analysis showed significant differences with HC, CO, and NOx from diesel ($p<=0.05$), and no significant difference was determined for CO_2 and PM.

- At 163,800 km (101,785 miles) when the diesel engine was removed from the truck,
  a) the condition of the engine obviously reflected the light load condition of use in the pickup;
  b) the engine was generally considered to be in a condition which could be characterized as good or better than that which would have been expected with diesel fuel;
  c) engine parts were clean and showed little wear;
  d) adverse effects were hardening of the crankshaft seals which made a slight depression where they made contact with the shaft; and rusting of the fuel filter attachment stud; and

e) the fuel pump, although showing varnish, was found to be in good condition in the bench test.

ACKNOWLEDGMENTS

The authors wish to acknowledge the cooperation of the Idaho Department of Water Resources who provided financial support for this project. Work on this project was also supported in part by USDA-ARS Specific Cooperative Agreement 58-6602-014; Lauren Dunlap, Ray Wilson and Harvey Porter at the Los Angeles Metropolitan Transit Authority, who actually conducted the emissions tests; and Craig Chase, a consultant to U.S. Department of Energy and the Pacific Northwest and Alaska Regional Bioenergy Program for his encouragement during this work and for finding financial support for the emissions tests.

DISCLAIMERS

Methanol is a hazardous material and can cause sickness or death when improperly handled. Methanol is also a serious fire hazard. Those handling methanol should be certain that all handling and storage equipment meets local fire codes. Users should obtain, keep handy, and follow the provisions of the applicable MSDS forms for Methanol and all other chemicals used.

Catalysts used in making Biodiesel are also toxic and should be handled with care. Consult the suppliers MSDS forms for applicable precautions.

Biodiesel is an experimental product and the toxicological properties have not been thoroughly investigated. Universal precautions should be observed in all situations.

Biodiesel (methly or ethyl ester of plant oils or animal fats) is a new fuel which is being tested under a wide range of conditions including both neat and blended with petrodiesel. Users of this fuel should be aware, however, that currently there is no fuel specification for Biodiesel and, therefore, engine manufacturers' published fuel specification requirements assume warranty liability for failure of components or emission certification traceable to the fuel. Non-fuel related warranty issues are not affected by the use of Biodiesel.

Users of Biodiesel should be aware that any private use in an on-road vehicle, whether purchased or privately produced from local materials, is subject to both federal and state road tax. In Idaho this would amount to 24.3 cents per gallon federal tax and 25 cents per gallon state tax. In Idaho, biodiesel is included in the law which allows up to 10% alternative fuel use without being subject to road tax. Check with the state tax commission for interpretation of the law in a specific case. Biodiesel fuel producers and users should contact local IRS offices and state tax agencies for road tax amounts and reporting requirements.

Anyone contemplating producing Biodiesel should be made aware of the regulations, taxes and hazards involved, only some of which are mentioned above. They should become aware of and practice good safety. They also will need to research all applicable laws relating to the production and sale of Biodiesel. The Biodiesel production methods reported in this report is for information purposes, is not necessarily suitable for use on a commercial or private scale, and should not be used by those lacking the technical background to do so in a safe manner.

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Appendix A

Oil Analysis Reports

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DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: X59
Condition: NORMAL
Analyst : RGT

MAKE: CUMMINS MODEL: DODGE
UNIT SERIAL NO:. X59

OIL BRAND: CHEVRON
OIL TYPE: DELO 15-40
FUEL TYPE: DIESEL
NO. COPIES: 2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS

VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
5000	02/06/96	?	7	1	1	1	0	2	0	0	0	3	135	4	24	2193	0	973	1130	0	0	0	0
	02/23/96	82612																					
8542	03/19/96	2831	6	0	2	1	0	2	0	0	0	1	149	2	21	2128	0	1020	1225	0	0	0	0
	03/26/96	85438																					
13093	05/03/96	3117	6	0	2	1	0	1	0	0	0	1	138	3	33	2164	0	1019	1213	0	0	0	0
	05/08/96	1801																					
30658	10/24/96	?	8	0	2	1	0	1	0	0	0	2	151	6	14	2167	0	1084	1247	0	0	0	0
	10/25/96	101937																					

PHYSICAL PROPERTY DATA

LAB#	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
5000	N/A	<1	N/A	13.22	0	N/A	NEG
8542	N/A	<1	N/A	12.82	0	N/A	NEG
13093	N/A	<1	N/A	13.70	0	N/A	NEG
30658	N/A	<1	N/A	14.07	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
5000	0.1	5.4	40
8542	0.2	5.5	40
13093	0.2	5.4	40
30658	0.1	5.8	40

PARTICLE COUNT RESULTS

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
5000	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
8542	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
13093	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
30658	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

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Chevron Lubricants

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: X59
Condition: NORMAL
Analyst : RGT

MAKE: CUMMINS MODEL: DODGE
UNIT SERIAL NO:. X59

OIL BRAND: CHEVRON
OIL TYPE: DELO 15-40
FUEL TYPE: DIESEL
NO. COPIES: 2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS

VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
32697	11/27/95 12/14/95	3261 78903	7	0	2	1	0	2	0	0	0	1	145	4	44	2355	0	934	1110	0	0	0	0
5000	02/06/96 02/23/96	? 82612	7	1	1	1	0	2	0	0	0	3	135	4	24	2193	0	973	1130	0	0	0	0
8542	03/19/96 03/26/96	2831 85438	6	0	2	1	0	2	0	0	0	1	149	2	21	2128	0	1020	1225	0	0	0	0
13093	05/03/96 05/08/96	3117 1801	6	0	2	1	0	1	0	0	0	1	138	3	33	2164	0	1019	1213	0	0	0	0

PHYSICAL PROPERTY DATA

LAB#	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
32697	N/A	<1	N/A	13.43	0	N/A	NEG
5000	N/A	<1	N/A	13.22	0	N/A	NEG
8542	N/A	<1	N/A	12.82	0	N/A	NEG
13093	N/A	<1	N/A	13.70	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
32697	0.2	5.6	40
5000	0.1	5.4	40
8542	0.2	5.5	40
13093	0.2	5.4	40

PARTICLE COUNT RESULTS

LAB# ANALYSIS RECOMMENDATIONS

32697 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

5000 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

LAB# ANALYSIS RECOMMENDATIONS

8542 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

13093 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

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DESCRIPTION: ENGINE

Chevron Lubricants

CUSTOMER NO.: 19562 UNIT NO.: X59
Condition: NORMAL
Analyst : RGT

MAKE: CUMMINS MODEL: DODGE
UNIT SERIAL NO:. X59

OIL BRAND: CHEVRON
OIL TYPE: DELO 15-40
FUEL TYPE: DIESEL NO. COPIES: 2

SAMPLE DATA

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT
26222	10/03/95	4422
	10/10/95	75642
32697	11/27/95	3261
	12/14/95	78903
5000	02/06/96	?
	02/23/96	82612
8542	03/19/96	2831
	03/26/96	85438

SPECTROCHEMICAL ANALYSIS
VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

LAB#	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
26222	7	0	1	1	0	2	0	0	0	1	142	0	43	2292	0	940	1124	0	0	0	0
32697	7	0	2	1	0	2	0	0	0	1	145	4	44	2355	0	934	1110	0	0	0	0
5000	7	1	1	1	0	2	0	0	0	3	135	4	24	2193	0	973	1130	0	0	0	0
8542	6	0	2	1	0	2	0	0	0	1	149	2	21	2128	0	1020	1225	0	0	0	0

PHYSICAL PROPERTY DATA

LAB#	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
26222	N/A	<1	N/A	13.36	0	N/A	NEG
32697	N/A	<1	N/A	13.43	0	N/A	NEG
5000	N/A	<1	N/A	13.22	0	N/A	NEG
8542	N/A	<1	N/A	12.82	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
26222	0.1	5.6	40
32697	0.2	5.6	40
5000	0.1	5.4	40
8542	0.2	5.5	40

PARTICLE COUNT RESULTS

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
26222	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
32697	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
5000	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
8542	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

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Chevron Lubricants

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: X59
Condition: NORMAL
Analyst : RGT

MAKE: CUMMINS MODEL: DODGE
UNIT SERIAL NO:. X59

OIL BRAND: CHEVRON
OIL TYPE: DELO 15-40
FUEL TYPE: DIESEL
NO. COPIES: 1

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS (VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT)

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
13651	06/20/95 06/21/95	3233 67836	6	0	1	1	0	3	0	0	0	4	159	0	44	2320	1	1041	1246	0	0	0	0
26222	10/03/95 10/10/95	4422 75642	7	0	1	1	0	2	0	0	0	1	142	0	43	2292	0	940	1124	0	0	0	0
32697	11/27/95 12/14/95	3261 78903	7	0	2	1	0	2	0	0	0	1	145	4	44	2355	0	934	1110	0	0	0	0
5000	02/06/96 02/23/96	? 82612	7	1	1	1	0	2	0	0	0	3	135	4	24	2193	0	973	1130	0	0	0	0

PHYSICAL PROPERTY DATA

LAB#	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
13651	N/A	<1	N/A	13.39	0	N/A	NEG
26222	N/A	<1	N/A	13.36	0	N/A	NEG
32697	N/A	<1	N/A	13.43	0	N/A	NEG
5000	N/A	<1	N/A	13.22	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
13651	0.1	5.8	40
26222	0.1	5.6	40
32697	0.2	5.6	40
5000	0.1	5.4	40

PARTICLE COUNT RESULTS

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
13651	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
26222	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
32697	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
5000	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

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AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION

LAB CONTROL NO.	MISC. INFO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	NICKEL NI	FUEL DILUTION (PHYSICAL TESTS)	ANTI-FREEZE (PHYSICAL TESTS)	WATER (PHYSICAL TESTS)	SAE OF SAMPLE (VISCOSITY) (PHYSICAL TESTS)	SOOT % ALLOWABLE (INFRARED)	OXIDATION % ALLOWABLE (INFRARED)	SULFUR % ALLOWABLE (INFRARED)	% ALLOWABLE NITRATION (INFRARED)
28257	28257	2/06/96	2/15/96		82612		15-40	1	1	3	1	1	1	1	2	1	1				40				
THESE ARE YOUR CURRENT RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
3883	3883	5/11/95	5/15/95				15-40	2	1	5	1	2	3	1	2	1					30				
THESE ARE YOUR PREVIOUS RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
95725	95725	2/16/95	2/20/95					2	1	4	1	2	4	1	2	1					30				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
86143	86143	10/25/94	10/31/94		52550	3232	15-40	1	1	3	1	2	2	1	2	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
80563	80563	8/17/94	8/23/94		49318	2846	15-40	1	1	5	1	2	2	1	1	1					30				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						

Chevron LubeWatch™
Maintenance Management System

(800) LUBE-808

11607 EAST TRENT AVENUE, SPOKANE, WASHINGTON 99206, (509) 921-9909, FAX (509) 921-9910

Chevron Lubricants

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562   UNIT NO.: X59
Condition: NORMAL
Analyst : RGT

MAKE: CUMMINS   MODEL: DODGE
UNIT SERIAL NO.: X59

OIL BRAND: CHEVRON
OIL TYPE: DELO 400 15-40
FUEL TYPE: DIESEL

NO. COPIES: 1

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS* / PHYSICAL PROPERTY DATA

*VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
87928	08/17/94 08/22/94	2850 49318	10	0	2	1	0	4	0	0	0	4	152	0	46	2261	0	1014	1297	0	0	0	0	N/A	<1	N/A	13.4	0	0.3	NEG
13651	06/20/95 06/21/95	3233 67836	6	0	1	1	0	3	0	0	0	4	159	0	44	2320	1	1041	1246	0	0	0	0	N/A	<1	N/A	13.39	0	N/A	NEG
26222	10/03/95 10/10/95	4422 75642	7	0	1	1	0	2	0	0	0	1	142	0	43	2292	0	940	1124	0	0	0	0	N/A	<1	N/A	13.36	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
87928			
13651	0.1	5.8	40
26222	0.1	5.6	40

PARTICLE COUNT RESULTS

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
87928	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
13651	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
26222	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

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Chevron Lubricants

11607 EAST TRENT AVENUE, SPOKANE, WASHINGTON 99206, (509) 921-9909, FAX (509) 921-9910

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562   UNIT NO.: X59   OIL BRAND: CHEVRON
Condition: NORMAL   MAKE: CUMMINS   MODEL: DODGE   OIL TYPE: DELO 400 15-40
Analyst : RGT   UNIT SERIAL NO.: X59   FUEL TYPE: DIESEL   NO. COPIES: 1

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS

VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MAGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDEUM	TITANIUM	VANADIUM	POTASSIUM
87928	08/17/94	2850	10	0	2	1	0	4	0	0	0	4	152	0	46	2261	0	1014	1297	0	0	0	0
	08/22/94	49318																					
13651	06/20/95	3233	6	0	1	1	0	3	0	0	0	4	159	0	44	2320	1	1041	1246	0	0	0	0
	06/21/95	67836																					

PHYSICAL PROPERTY DATA

LAB#	FLASH	FUEL % Vol	VIS 40° C	VIS 100° C	WATER % Vol	SOLIDS % Vol	GLYCOL
87928	N/A	<1	N/A	13.4	0	0.3	NEG
13651	N/A	<1	N/A	13.39	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
87928			
13651	0.1	5.8	40

PARTICLE COUNT RESULTS

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
87928	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
13651	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	WEAR METALS ARE REPORTED IN PARTS PER MILLION: LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	PHYSICAL TESTS: FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	INFRARED: SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
3883	3883	5/11/95	5/15/95				15-40	2	1	5	1	2	3	1	2	1					30				
THESE ARE YOUR CURRENT RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
95725	95725	2/16/95	2/20/95					2	1	4	1	2	4	1	2	1					30				
THESE ARE YOUR PREVIOUS RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
86143	86143	10/25/94	10/31/94		52550	3232	15-40	1	1	3	1	2	2	1	2	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
80563	80563	8/17/94	8/23/94		49318	2846	15-40	1	1	5	1	2	2	1	1	1					30				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
99202	99202	0/00/00	3/30/95				15-40	1	1	3	1	1	3	1	3	1					30				
THESE ARE YOUR CURRENT RESULTS	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
95725	95725	2/16/95	2/20/95					2	1	4	1	2	4	1	2	1					30				
THESE ARE YOUR PREVIOUS RESULTS	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
90138	90138	0/00/00	12/21/94				15-40	2	1	4	1	2	3	1	3	1					30				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
86143	86143	10/25/94	10/31/94		52550	3232	15-40	1	1	3	1	2	2	1	2	1					40				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
80563	80563	8/17/94	8/23/94		49318	2846	15-40	1	1	5	1	2	2	1	1	1					30				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
74675	74675	6/09/94	6/13/94		46472	3250	15-40	1	6	4	1	2	1	1	3	1					40				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION (PHYSICAL TESTS)	ANTI-FREEZE (PHYSICAL TESTS)	WATER (PHYSICAL TESTS)	SAE OF SAMPLE (VISCOSITY) (PHYSICAL TESTS)	SOOT % ALLOWABLE (INFRARED)	OXIDATION % ALLOWABLE (INFRARED)	SULFUR % ALLOWABLE (INFRARED)	% ALLOWABLE NITRATION (INFRARED)
95725	95725	2/16/95	2/20/95					2	1	4	1	2	4	1	2	1					30				
THESE ARE YOUR CURRENT RESULTS	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
90138	90138	0/00/00	12/21/94				15-40	2	1	4	1	2	3	1	3	1					30				
THESE ARE YOUR PREVIOUS RESULTS	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
86143	86143	10/25/94	10/31/94		52550	3232	15-40	1	1	3	1	2	2	1	2	1					40				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
80563	80563	8/17/94	8/23/94		49318	2846	15-40	1	1	5	1	2	2	1	1	1					30				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
74675	74675	6/09/94	6/13/94		46472	3250	15-40	1	6	4	1	2	1	1	3	1					40				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
71938	71938	0/00/00	5/06/94				15-40	1	1	4	1	1	2	1	4	1					30				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
90138	90138	0/00/00	12/21/94				15-40	2	1	4	1	2	3	1	3	1					30				
THESE ARE YOUR CURRENT RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
86143	86143	10/25/94	10/31/94		52550	3232	15-40	1	1	3	1	2	2	1	2	1					40				
THESE ARE YOUR PREVIOUS RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
80563	80563	8/17/94	8/23/94		49318	2846	15-40	1	1	5	1	2	2	1	1	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
74675	74675	6/09/94	6/13/94		46472	3250	15-40	1	6	4	1	2	1	1	3	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
71938	71938	0/00/00	5/06/94				15-40	1	1	4	1	1	2	1	4	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
66314	66314	2/18/94	2/23/94		36215	3394	15-40	1	1	6	1	2	2	1	17	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

CLEVELAND TECHNICAL CENTER

11607 E. TRENT AVENUE • SPOKANE, WASHINGTON 99206 • (509) 921-9909

CUSTOMER NO. 19562 UNIT NO. X059

DESCRIPTION ENGINE

MAKE DODGE MODEL RAM 250

UNIT SERIAL NO.

OIL BRAND CHEVRON DELO NUMBER COPIES 1

OIL TYPE 15W40

FUEL TYPE DIESEL

Condition: NORMAL
Analyst : RGT

SAMPLE DATA

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT
92007	10/25/94 10/31/94	3232 52550

SPECTROCHEMICAL ANALYSIS
VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
7	0	2	1	0	3	0	0	0	4	153	0	37	2244	0	945	1252	0	0	0	0

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol	VIS 40°C cSt	VIS 100°C cSt	WATER %Vol	SOLIDS %Vol	GLYCOL
N/A	<1	N/A	13.31	0	0.1	NEG

ADDITIONAL CUSTOMER TESTS

LAB#										
92007										

PARTICLE COUNT RESULTS

ANALYSIS RECOMMENDATIONS

LAB#

ANALYSIS RECOMMENDATIONS

LAB#

92007 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

WHEN CORRECTIVE ACTION IS INDICATED, PLEASE ADVISE RESULTS OF YOUR FINDINGS AND CORRECTIVE ACTION TAKEN ON ENCLOSED FORM.

SP-100
[illegible]/94

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
459	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
86143	86143	10/25/94	10/31/94		52550	3232	15-40	1	1	3	1	2	2	1	2	1					40				
THESE ARE YOUR CURRENT RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
80563	80563	8/17/94	8/23/94		49318	2844	15-40	1	1	5	1	2	2	1	1	1					30				
THESE ARE YOUR PREVIOUS RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
74675	74675	6/09/94	6/13/94		46472	3250	15-40	1	6	4	1	2	1	1	3	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
71938	71938	0/00/00	5/06/94				15-40	1	1	4	1	1	2	1	4	1					30				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
66314	66314	2/18/94	2/23/94		36215	3394	15-40	1	1	6	1	2	2	1	17	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
63211	63211	1/05/94	1/11/94		32821	2838	15-40	1	1	8	1	2	3	1	4	1					30				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	WEAR METALS ARE REPORTED IN PARTS PER MILLION: LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	PHYSICAL TESTS: FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	INFRARED: SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
80563	80563	8/17/94	8/23/94		49318	2846	15-40	1	1	5	1	2	2	1	1	1					30				
THESE ARE YOUR CURRENT RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
74675	74675	6/09/94	6/13/94		46472	3250	15-40	1	6	4	1	2	1	1	3	1					40				
THESE ARE YOUR PREVIOUS RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
71938	71938	0/00/00	5/06/94				15-40	1	1	4	1	1	2	1	4	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
66314	66314	2/18/94	2/23/94		36215	3394	15-40	1	1	6	1	2	2	1	17	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
63211	63211	1/05/94	1/11/94		32821	2838	15-40	1	1	8	1	2	3	1	4	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
58472	58472	10/22/93	10/26/93				15-40	3	1	12	1	2	2	1	15	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

Chevron LubeWatch
Maintenance Management System

(800) LUBE-808

Chevron Lubricants

DESCRIPTION ENGINE

CUSTOMER NO. 19562   UNIT NO. X59

Condition: NORMAL

Analyst : RGT

MAKE CUMMINS   MODEL DODGE

UNIT SERIAL NO. X59

OIL BRAND CHEVRON   NUMBER COPIES 2

OIL TYPE 15-40   TYPE SERVICE

FUEL TYPE DIESEL

SAMPLE DATA

LAB#	DATE TAKEN/ RECEIVED	HRS/MI OIL UNIT
87928	08/17/94 08/22/94	2850 49318

SPECTROCHEMICAL ANALYSIS — VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
10	0	2	1	0	4	0	0	0	4	152	0	46	2261	0	1014	1297	0	0	0	0

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol	VIS 40°C cSt	VIS 100°C cSt	WATER %Vol	SOLIDS %Vol	GLYCOL
N/A	<1	N/A	13.4	0	0.3	NEG

ADDITIONAL CUSTOMER TESTS

LAB#										
87928										

PARTICLE COUNT RESULTS

LAB#	ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
87928	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

DAVE
BUSCH DIST
MOSCOW, ID 83843

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	WEAR METALS ARE REPORTED IN PARTS PER MILLION: LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	PHYSICAL TESTS: FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	INFRARED: SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
74675	74675	6/09/94	6/13/94		46472	3250	15-40	1	6	4	1	2	1	1	3	1					40				
THESE ARE YOUR CURRENT RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
71938	71938	0/00/00	5/06/94				15-40	1	1	4	1	1	2	1	4	1					30				
THESE ARE YOUR PREVIOUS RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
66314	66314	2/18/94	2/23/94		36215	3394	15-40	1	1	6	1	2	2	1	17	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
63211	63211	1/05/94	1/11/94		32821	2838	15-40	1	1	8	1	2	3	1	4	1					30				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
58472	58472	10/22/93	10/26/93				15-40	3	1	12	1	2	2	1	15	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
56658	56658	9/23/93	9/29/93		26849	3016	15-40	2	4	5	1	2	2	1	6	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
71938	71938	0/00/00	5/06/94				15-40	1	1	4	1	1	2	1	4	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
THESE ARE YOUR CURRENT RESULTS																									
66314	66314	2/18/94	2/23/94		36215	3394	15-40	1	1	6	1	2	2	1	17	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
THESE ARE YOUR PREVIOUS RESULTS																									
63211	63211	1/05/94	1/11/94		32821	2838	15-40	1	1	8	1	2	3	1	4	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
58472	58472	10/22/93	10/26/93				15-40	3	1	12	1	2	2	1	13	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
56658	56658	9/23/93	9/29/93		26849	3016	15-40	2	4	5	1	2	2	1	6	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
51470	51470	7/09/93	7/12/93		23833		15-40	2	18	5	1	7	5	2	19	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
66314	66314	2/18/94	2/23/94		36215	3394	15-40	1	1	6	1	2	2	1	17	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
63211	63211	1/05/94	1/11/94		32821	2838	15-40	1	1	8	1	2	3	1	4	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
58472	58472	10/22/93	10/26/93				15-40	3	1	12	1	2	2	1	15	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
56658	56658	9/23/93	9/29/93		26849	3016	15-40	2	4	5	1	2	2	1	6	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
51470	51470	7/09/93	7/12/93		23833		15-40	2	18	5	1	7	5	2	19	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
49530	49530	6/07/93	6/11/93		20522	2800	15-40	1	21	5	1	1	2	1	17	1					40	1	9	1	6
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION — PHYSICAL TESTS — INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	NITRATION % ALLOWABLE
THESE ARE YOUR CURRENT RESULTS																									
63211	63211	1/05/94	1/11/94		32821	2838	15-40	1	1	8	1	2	3	1	4	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
BELOW ARE YOUR PREVIOUS RESULTS																									
58472	58472	10/22/93	10/26/93		29983	3134	15-40	3	1	12	1	2	2	1	15	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
56658	56658	9/23/93	9/29/93		26849	3016	15-40	2	4	5	1	2	2	1	6	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
51470	51470	7/09/93	7/12/93		23833		15-40	2	18	5	1	7	5	2	19	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
49530	49530	6/07/93	6/11/93		20522	2800	15-40	1	21	5	1	1	2	1	17	1					40	1	9	1	6
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
46648	46648	4/27/93	4/28/93		17188		15-40	1	9	5	1	1	2	1	17	1					500	1	4	4	10
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION — PHYSICAL TESTS — INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
58472	58472	10/22/93	10/26/93		29983	3134	15-40	3	1	12	1	2	2	1	15	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
56658	56658	9/23/93	9/29/93		26849	3016	15-40	2	4	5	1	2	2	1	6	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
51470	51470	7/09/93	7/12/93		23833		15-40	2	18	5	1	7	5	2	19	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
49530	49530	6/07/93	6/11/93		20522	2800	15-40	1	21	5	1	1	2	1	17	1					40	1	9	1	6
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
46648	46648	4/27/93	4/28/93				15-40	1	9	5	1	1	2	1	17	1					500	1	4	4	10
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
43645	43645	3/14/93	3/15/93		14764	3462	15-40	1	18	7	1	1	1	1	10	1					40	1	4	6	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
56658	56658	9/23/93	9/29/93		26849	3016	15-40	2	4	5	1	2	2	1	6	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
51470	51470	7/09/93	7/12/93		23833		15-40	2	18	5	1	7	5	2	19	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
49530	49530	6/07/93	6/11/93		20522	2800	15-40	1	21	5	1	1	2	1	17	1					40	1	9	1	6
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
46648	46648	4/27/93	4/28/93				15-40	1	9	5	1	1	2	1	17	1					500	1	4	4	10
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
43645	43645	3/14/93	3/15/93		14764	3462	15-40	1	18	7	1	1	1	1	10	1					40	1	4	6	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
39829	39829	1/08/93	1/11/93		11302	3139	15-40	3	1	8	1	2	3	2	9	1					40	9	10	12	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
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ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION | PHYSICAL TESTS | INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
					THESE ARE YOUR CURRENT RESULTS																				
51470	51470	7/09/93	7/12/93		23833		15-40	2	18	5	1	7	5	2	19	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
					BELOW ARE YOUR PREVIOUS RESULTS																				
49530	49530	6/07/93	6/11/93		20522	2800	15-40	1	21	5	1	1	2	1	17	1					40	1	9	1	6
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
46648	46648	4/27/93	4/28/93				15-40	1	9	5	1	1	2	1	17	1					500	1	4	4	10
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
43645	43645	3/14/93	3/15/93		14764	3462	15-40	1	18	7	1	1	1	1	10	1					40	1	4	6	9
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
39829	39829	1/08/93	1/11/93		11302	3139	15-40	3	1	8	1	2	3	2	9	1					40	9	10	12	9
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
36503	36503	11/09/92	11/10/92		8163		15-40	1	2	7	1	1	2	1	8	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

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UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	WEAR METALS ARE REPORTED IN PARTS PER MILLION: LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	PHYSICAL TESTS: FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	INFRARED: SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
49530	49530	6/07/93	6/11/93		20522	2800	15-40	1	21	5	1	1	2	1	17	1					40	1	9	1	6
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
46648	46648	4/27/93	4/28/93				15-40	1	9	5	1	1	2	1	17	1					500	1	4	4	10
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
43645	43645	3/14/93	3/15/93		14764	3462	15-40	1	18	7	1	1	1	1	10	1					40	1	4	6	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
39829	39829	1/08/93	1/11/93		11302	3139	15-40	3	1	8	1	2	3	2	9	1					40	9	10	12	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
36503	36503	11/09/92	11/10/92		8163		15-40	1	2	7	1	1	2	1	8	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
34315	34315	10/05/92	10/06/92		4492		15-40	2	5	10	1	2	3	1	9	10					550	14	5	9	1
ALL ELEMENTS APPEAR TO BE NORMAL. NO PROBLEMS INDICATED. RESAMPLE AT A NORMAL INTERVAL.																									

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Western States **CAT**

General Office
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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

oil change period
miles
new oil

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
46648	46648	4/27/93	4/28/93		17788		15-40	1	9	5	1	1	2	1	17	1					500	1	4	4	10
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
								0-30	0-50	100	10	0-15	7-20	0-30	<100	0-150						100%			
BELOW ARE YOUR PREVIOUS RESULTS																									
43645	43645	3/14/93	3/15/93		14764	3462	15-40	1	18	7	1	1	1	1	10	1					40	1	4	6	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
39829	39829	1/08/93	1/11/93		11302	3139	15-40	3	1	8	1	2	3	2	9	1					40	9	10	12	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
36503	36503	11/09/92	11/10/92		8163		15-40	1	2	7	1	1	2	1	8	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
34315	34315	10/05/92	10/06/92		4492		15-40	2	5	10	1	2	3	1	9	10					550	14	5	9	1
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									
31254	31254	8/11/92	8/13/92		1638	1638		1	18	10	1	2	4	1	3	101					400	1	53	51	22
ALL ELEMENTS APPEAR TO BE NORMAL FOR NEW ENGINE BREAKIN RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
39829	39829	1/08/93	1/11/93		11302	3139	15-40	3	1	8	1	2	3	2	9	1					40	9	10	12	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
36503	36503	11/09/92	11/10/92		8163		15-40	1	2	7	1	1	2	1	8	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
34315	34315	10/05/92	10/06/92		4492		15-40	2	5	10	1	2	3	1	9	10					550	14	5	9	1
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									
31254	31254	8/11/92	8/13/92		1638	1638		1	18	10	1	2	4	1	3	101					400	1	53	51	22
ALL ELEMENTS APPEAR TO BE NORMAL FOR NEW ENGINE BREAKIN RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
36503	36503	11/09/92	11/10/92		8163		15-40	1	2	7	1	1	2	1	8	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
34315	34315	10/05/92	10/06/92		4492		15-40	3	5	10	1	2	3	1	9	10					550	14	5	9	1
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									
31254	31254	8/11/92	8/13/92		1638	1638		1	18	10	1	2	4	1	3	101					400	1	53	51	22
ALL ELEMENTS APPEAR TO BE NORMAL FOR NEW ENGINE BREAKIN RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

GE5548

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
34315	34315	10/05/92	10/06/92		4492		15-40	2	5	10	1	2	3	1	9	10					550	14	5	9	1
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									
BELOW ARE YOUR PREVIOUS RESULTS																									
31254	31254	8/11/92	8/13/92		1639	1638		1	18	10	1	2	4	1	3	101					400	1	53	51	22
ALL ELEMENTS APPEAR TO BE NORMAL FOR NEW ENGINE BREAKIN RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	31254	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
X59	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
31254	31254	8/11/92	8/13/92		1638	1638		1	18	10	1	2	4	1	3	101					400	1	53	51	22

ALL ELEMENTS APPEAR TO BE NORMAL
FOR NEW ENGINE BREAKIN
RESAMPLE AT A NORMAL INTERVAL

BELOW ARE YOUR PREVIOUS RESULTS

Appendix B

Check Vehicle
Oil Analysis Reports
(For comparison only)

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	46089	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
6-01	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
46089	46089	4/13/93	4/20/93		34911	3074	15-40	1	1	11	1	3	1	1	10	1					40	4	15	19	10
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									

CLEVELAND TECHNICAL CENTER

EAST 9514 MONTGOMERY STREET, BAY 31 • SPOKANE, WA 99206 • 509-921-9909

PARENT NO.	CLIENT NO.	UNIT NO.	UNIT TYPE			OTHER
5006	23	6-01	E			

E—ENGINE
T—TRANS
H—HYD
D—DIFF
G—GEAR BOX

L—LEFT
R—RIGHT
C—CENTER

F—FRONT
B—BACK

DESCRIPTION

MAKE CUMMINS MODEL 5L9 TURBO
UNIT SERIAL NO. IB7KM26CIMS365856

OIL BRAND CHEVRON DELO
OIL TYPE 400 15-40
FUEL TYPE DIESEL

NUMBER COPIES 2
TYPE SERVICE P2

SAMPLE DATA

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT
823	19MAY93	3503
	21MAY93	38414
500	12JUL93	4695
	15JUL93	43109
563	18AUG93	3062
	20AUG93	46171
132	23FEB94	4000
	03MAR94	58200

SPECTROCHEMICAL ANALYSIS
VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER		SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM			
21	1	5	2	3	6	1	0		4	204	33	105	2616	1	1224	1348	1			
34	2	9	4	6	10	1	6		4	222	40	0	2829	1	1193	1434	1			
15	1	8	2	4	5	1	1		3	205	30	0	2511	0	1202	1399	1			
13	1	0	1	5	3	0	0		2	179	13	0	2495	0	1053	1283	0			

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol.	VIS 40°C cSt	VIS 100°C cSt	WATER % Vol.	SOLIDS % Vol.	GLYCOL
N/A	<1	N/A	12.9	<1	<1	NEG
N/A	<1	N/A	13.6	<1	<1	NEG
N/A	<1	N/A	14.1	<1	<1	NEG
N/A	<1	N/A	12.8	0	.1	NEG

ADDITIONAL CUSTOMER TESTS

LAB#										
823										
500										
563										
132										

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
823	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
500	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
563	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
132	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DALE REECE
UNIVERSITY OF IDAHO
AG ENG. BLDG AEL B1
MOSCOW ID 83843

UNIT 6-01

WHEN CORRECTIVE ACTION IS INDICATED, PLEASE ADVISE RESULTS OF YOUR FINDINGS AND CORRECTIVE ACTION TAKEN ON ENCLOSED FORM.

CLEVELAND TECHNICAL CENTER

EAST 9514 MONTGOMERY STREET, BAY 31 • SPOKANE, WA 99206 • 509-921-9909

East to Argonne exit #287
2nd light N over Freway 3rd light right

PARENT NO.	CLIENT NO.	UNIT NO.	UNIT TYPE	OTHER
5006	23	6-01	E	

E—ENGINE T—TRANS H—HYD D—DIFF G—GEAR BOX | L—LEFT R—RIGHT C—CENTER | F—FRONT B—BACK

DESCRIPTION

MAKE CUMMINS MODEL 5L9 TURBO

UNIT SERIAL NO. 1B7KM26C1MS365856

OIL BRAND CHEVRON DELO
OIL TYPE 400 15-40
FUEL TYPE DIESEL

NUMBER COPIES 2
TYPE SERVICE P2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS (VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT)

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER		SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM			
508	13APR93	3074	23	1	15	3	4	6	2	2		5	238	46	0	2172	1	1162	1246	4			
	15APR93	34911																					
823	19MAY93	3503	21	1	5	2	3	6	1	0		4	204	33	105	2616	1	1224	1348	1			
	21MAY93	38414																					
500	12JUL93	4695	34	2	9	4	6	10	1	6		4	222	40	0	2829	1	1193	1434	1			
	15JUL93	43109																					
563	18AUG93	3062	15	1	8	2	4	5	1	1		3	205	30	0	2511	0	1202	1399	1			
	20AUG93	46171																					

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol.	VIS 40°C cSt	VIS 100°C cSt	WATER % Vol.	SOLIDS % Vol.	GLYCOL
N/A	<1	N/A	12.8	<1	<1	NEG
N/A	<1	N/A	12.9	<1	<1	NEG
N/A	<1	N/A	13.6	<1	<1	NEG
N/A	<1	N/A	14.1	<1	<1	NEG

ADDITIONAL CUSTOMER TESTS

LAB#										
508										
823										
500										
563										

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
508	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
823	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
500	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
563	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DALE REECE
UNIVERSITY OF IDAHO
AG ENG. BLDG AEL 81
MOSCOW ID 83843

UNIT 6-01

WHEN CORRECTIVE ACTION IS INDICATED, PLEASE ADVISE RESULTS OF YOUR FINDINGS AND CORRECTIVE ACTION TAKEN ON ENCLOSED FORM.

CLEVELAND TECHNICAL CENTER

EAST 9514 MONTGOMERY STREET, BAY 31 • SPOKANE, WA 99206 • 509-921-9909

PARENT NO.	CLIENT NO.	UNIT NO.	UNIT TYPE			OTHER
5006	23	6-01	E			

E—ENGINE, T—TRANS, H—HYD, D—DIFF, G—GEAR BOX
L—LEFT, R—RIGHT, C—CENTER
F—FRONT, B—BACK

DESCRIPTION
MAKE CUMMINS
MODEL 5L9 TURBO
UNIT SERIAL NO.

OIL BRAND CHEVRON DELO
OIL TYPE 400 15-40
FUEL TYPE DIESEL

NUMBER COPIES 2
TYPE SERVICE F2

SAMPLE DATA

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT
1133	31DEC92	3713
	02JAN93	28696
810	22FEB93	3141
	23FEB93	31837
508	13APR93	3074
	15APR93	34911

SPECTROCHEMICAL ANALYSIS
VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER		SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM			
25	3	1	2	3	5	0	4		3	179	22	14	2232	28	1084	1250	3			
11	5	7	4	1	5	0	0		5	231	16	82	2007	65	1103	1227	1			
23	1	15	3	4	6	2	2		5	238	46	0	2172	1	1162	1246	4			

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol.	VIS 40°C cSt	VIS 100°C cSt	WATER % Vol.	SOLIDS % Vol.	GLYCOL
N/A	<1	N/A	13.0	<1	<1	NEG
N/A	<1	N/A	12.8	<1	<1	NEG
N/A	<1	N/A	12.8	<1	<1	NEG

ADDITIONAL CUSTOMER TESTS

LAB#										
1133										
810										
508										

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
1133	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
810	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
508	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DALE REECE
UNIVERSITY OF IDAHO
AG ENG. BLDG AEL 81
MOSCOW ID 83843

UNIT 6-01

WHEN CORRECTIVE ACTION IS INDICATED, PLEASE ADVISE RESULTS OF YOUR FINDINGS AND CORRECTIVE ACTION TAKEN ON ENCLOSED FORM.

CLEVELAND TECHNICAL CENTER

EAST 9514 MONTGOMERY STREET, BAY 31 • SPOKANE, WA 99206 • 509-921-9909

PARENT NO.	CLIENT NO.	UNIT NO.	UNIT TYPE			OTHER
5006	23	6-01	E			

E—ENGINE
T—TRANS.
H—HYD.
D—DIFF
G—GEAR BOX

L—LEFT
R—RIGHT
C—CENTER

F—FRONT
B—BACK

DESCRIPTION

MAKE CUMMINS MODEL 5L9 TURBO
UNIT SERIAL NO. IB7KM26CIMS365B56

OIL BRAND CHEVRON DELO
OIL TYPE 400 15-40
FUEL TYPE DIESEL

NUMBER COPIES 2
TYPE SERVICE P2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS

VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER		SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM			
1133	31DEC92	3713	25	3	1	2	3	5	0	4		3	179	22	14	2232	28	1084	1250	3			
	02JAN93	28696																					
810	22FEB93	3141	11	5	7	4	1	5	0	0		5	231	16	82	2007	65	1103	1227	1			
	23FEB93	31837																					
508	13APR93	3074	23	1	15	3	4	6	2	2		5	238	46	0	2172	1	1162	1246	4			
	15APR93	34911																					
823	19MAY93	3503	21	1	5	2	3	6	1	0		4	204	33	105	2616	1	1224	1348	1			
	21MAY93	38414																					

PHYSICAL PROPERTY DATA

LAB#	FLASH	FUEL % Vol.	VIS 40°C cSt	VIS 100°C cSt	WATER % Vol.	SOLIDS % Vol.	GLYCOL
1133	N/A	<1	N/A	13.0	<1	<1	NEG
810	N/A	<1	N/A	12.8	<1	<1	NEG
508	N/A	<1	N/A	12.8	<1	<1	NEG
823	N/A	<1	N/A	12.9	<1	<1	NEG

ADDITIONAL CUSTOMER TESTS

LAB#										
1133										
810										
508										
823										

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
1133	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
810	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
508	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
823	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DALE REECE
UNIVERSITY OF IDAHO
AG ENG. BLDG AEL 81
MOSCOW ID 83843

UNIT 6-01

WHEN CORRECTIVE ACTION IS INDICATED, PLEASE ADVISE RESULTS OF YOUR FINDINGS AND CORRECTIVE ACTION TAKEN ON ENCLOSED FORM.

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	46089	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
6-01	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION | PHYSICAL TESTS | INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
48463	48463	5/19/93	5/27/93		38414	3503	15-40	9	1	26	1	5	4	3	17	1					30				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
46089	46089	4/13/93	4/20/93		34911	3074	15-40	1	1	11	1	3	1	1	10	1					40	4	15	19	10
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									

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PARENT NO.	CLIENT NO.	UNIT NO.	UNIT TYPE	OTHER
5006	23	6-01	E	

E--ENGINE T--TRANS H--HYD D--DIFF. G--GEAR BOX

L--LEFT R--RIGHT C--CENTER

F--FRONT B--BACK

DESCRIPTION

MAKE CUMMINS MODEL 5L9 TURBO

UNIT SERIAL NO. IB7KM26CIMS365856

OIL BRAND CHEVRON DELO NUMBER COPIES 2

OIL TYPE 400 15-40 TYPE SERVICE P2

FUEL TYPE DIESEL

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS

VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER		SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM
810	22FEB93	3141	11	5	7	4	1	5	0	0		5	231	16	82	2007	65	1103	1227	1
	23FEB93	31837																		
508	13APR93	3074	23	1	15	3	4	6	2	2		5	238	46	0	2172	1	1162	1246	4
	15APR93	34911																		
823	19MAY93	3503	21	1	5	2	3	6	1	0		4	204	33	105	2616	1	1224	1348	1
	21MAY93	38414																		
500	12JUL93	4695	34	2	9	4	6	10	1	6		4	222	40	0	2829	1	1193	1434	1
	15JUL93	43109																		

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol.	VIS 40°C cSt	VIS 100°C cSt	WATER % Vol.	SOLIDS % Vol.	GLYCOL
N/A	<1	N/A	12.8	<1	<1	NEG
N/A	<1	N/A	12.8	<1	<1	NEG
N/A	<1	N/A	12.9	<1	<1	NEG
N/A	<1	N/A	13.6	<1	<1	NEG

ADDITIONAL CUSTOMER TESTS

LAB#
810
508
823
500

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
810	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
508	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
823	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
500	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DALE REECE
UNIVERSITY OF IDAHO
AG ENG. BLDG AEL 81
MOSCOW ID 83843

UNIT 6-01

WHEN CORRECTIVE ACTION IS INDICATED, PLEASE ADVISE RESULTS OF YOUR FINDINGS AND CORRECTIVE ACTION TAKEN ON ENCLOSED FORM.

CI-100

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	46089	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
6-01	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
					THESE ARE YOUR CURRENT RESULTS																				
51809	51809	7/12/93	7/15/93		43109	4695	15-40	1	1	19	1	4	3	1	14	1			✓	✓	40	1	10	23	15
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
					BELOW ARE YOUR PREVIOUS RESULTS																				
48463	48463	5/19/93	5/27/93		38414	3503	15-40	9	1	26	1	5	4	3	17	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
46089	46089	4/13/93	4/20/93		34911	3074	15-40	1	1	11	1	3	1	1	10	1					40	4	15	19	10
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
								15	3	23	1	6	5	4	46	4	1246								

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McGregor Dodge

PARENT NO.	CLIENT NO.	UNIT NO.	UNIT TYPE			OTHER
5006	23	6-01	E			

E—ENGINE, T—TRANS., H—HYD., D—DIFF, G—GEAR BOX
L—LEFT, R—RIGHT, C—CENTER
F—FRONT, B—BACK

DESCRIPTION
MAKE CUMMINS
MODEL 5L9 TURBO
UNIT SERIAL NO.
OIL BRAND CHEVRON DELO
OIL TYPE 400 15-40
FUEL TYPE DIESEL
NUMBER COPIES 2
TYPE SERVICE P2

SAMPLE DATA

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL	HRS/MI UNIT
1133	31DEC92	3713	
	02JAN93	28696	
810	22FEB93	3141	
	23FEB93	31837	

SPECTROCHEMICAL ANALYSIS
VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT

IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER		SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM			
25	3	1	2	3	5	0	4		3	179	22	14	2232	28	1084	1250	3			
11	5	7	4	1	5	0	0		5	231	16	82	2007	65	1103	1227	1			

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol.	VIS 40°C cSt	VIS 100°C cSt	WATER % Vol.	SOLIDS % Vol.	GLYCOL
N/A	<1	N/A	13.0	<1	<1	NEG
N/A	<1	N/A	12.8	<1	<1	NEG

ADDITIONAL CUSTOMER TESTS

LAB#										
1133										
810										

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS

ANALYSIS RECOMMENDATIONS

LAB#	ANALYSIS RECOMMENDATIONS
1133	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
810	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

GEORGE
MCGREGOR CO
RT 1 BOX 153
PALOUSE WA 99161

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

IDAHO BEVERAGE
2108 1ST AVE

LEWISTON ID 83501

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	542123	LEWISTON, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
39571	39571	12/31/92	1/06/93			300	15-40	1	1	4	1	1	1	1	7	1					30	8	15	15	15

ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS.
RESAMPLE AT NEXT NORMAL INTERVAL.

BELOW ARE YOUR PREVIOUS RESULTS

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION | PHYSICAL TESTS | INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
46557	46557	4/22/93	4/27/93	5	35455	3831	15-40	1	1	9	1	2	1	1	10	1					500	1	17	19	19
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
36036	36036	11/01/92	11/04/92	2	25,629	2995	15-40	1	1	6	1	1	1	1	6	1					525	1	14	16	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
33577	33577	9/18/92	9/23/92	1	3000	22629	15-40	2	2	8	1	2	2	1	9	1					550	1	36	21	20
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

IDAHO BEVERAGE
2108 1ST AVE

LEWISTON ID 83501

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	542123	LEWISTON, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION | PHYSICAL TESTS | INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
43278	43278	3/02/93	3/08/93	4	31624	4089	15-40	1	2	9	1	2	2	1	11	1					40	1	17	22	19
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
39571	39571	12/31/92	1/06/93	3	28,624	3000	15-40	1	1	6	1	1	1	1	7	1					30	8	15	15	15
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
62977	62977	1/03/94	1/07/94		53342	4369	15-40	1	1	6	1	2	2	1	2	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
58422	58422	10/19/93	10/25/93		48973	4662	15-40	3	2	9	1	3	2	1	5	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
46557	46557	4/22/93	4/27/93	✓		3831	15-40	1	1	9	1	2	1	1	10	1					500	1	17	19	19
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
36036	36036	11/01/92	11/04/92	✓		2995	15-40	1	1	6	1	1	1	1	6	1					525	1	14	16	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
33577	33577	9/18/92	9/23/92	✓	3000		15-40	2	2	8	1	2	2	1	9	1					550	1	36	21	20
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
10182	10182	7/20/95	7/26/95		96393		15-40	1	1	17	1	5	3	1	3	1					40				
THESE ARE YOUR CURRENT RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
1099	1099	4/07/95	4/17/95		87787	5600	15-40	1	2	9	1	4	2	1	4	1					40				
THESE ARE YOUR PREVIOUS RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
94227	94227	1/27/95	2/02/95		82100	3565	15-40	1	1	6	1	3	3	1	6	1					30				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
89320	89320	12/05/94	12/09/94		78533	6205	15-40	2	1	5	1	1	2	1	1	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
82845	82845	9/15/94	9/22/94		72326	5775	15-40	1	1	9	1	3	2	1	3	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
77159	77159	7/08/94	7/14/94		66550	5225	15-40	1	1	6	1	2	2	1	3	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
[illegible]	[illegible]	[illegible]	[illegible]

OWNER UNIT NO.	COMPARTMENT
	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

LAB CONTROL NO.	MISC. INFO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	WEAR METALS ARE REPORTED IN PARTS PER MILLION: LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	NICKEL NI	PHYSICAL TESTS: FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	INFRARED: SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
19041	19041	10/26/95	11/02/95		110470	[illegible]	15-40	1	4	13	1	5	3	1	5	1					40				
THESE ARE YOUR CURRENT RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
10182	10182	7/20/95	7/26/95		96393		15-40	1	1	17	1	5	3	1	3	1					40				
THESE ARE YOUR PREVIOUS RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
1099	1099	4/07/95	4/17/95		87787	5600	15-40	1	2	9	1	4	2	1	4	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
94227	94227	1/27/95	2/02/95		82100	3565	15-40	1	1	6	1	3	3	1	6	1					30				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
89320	89320	12/05/94	12/09/94		78533	6205	15-40	1	1	5	1	1	2	1	1	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
82845	82845	9/15/94	9/22/94		72326	5775	15-40	1	1	9	1	3	2	1	3	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						

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FAX 208-888-3932

SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION | PHYSICAL TESTS | INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
					THESE ARE YOUR CURRENT RESULTS																				
58422	58422	10/19/93	10/25/93		48972	4662	15-40	3	2	9	1	3	2	1	5	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
					BELOW ARE YOUR PREVIOUS RESULTS																				
46557	46557	4/22/93	4/27/93			3831	15-40	1	1	9	1	2	1	1	10	1					500	1	17	19	19
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
36036	36036	11/01/92	11/04/92			2995	15-40	1	1	6	1	1	1	1	6	1					525	1	14	16	9
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
33577	33577	9/18/92	9/23/92		3000		15-40	2	2	8	1	2	2	1	9	1					550	1	36	21	20
				ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																					

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

Pepsi Cola

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION | PHYSICAL TESTS | INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
36036	36036	11/01/92	11/04/92			2995	15-40	1	1	4	1	1	1	1	6	1					525	1	14	16	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
33577	33577	9/18/92	9/23/92		3000		15-40	2	2	8	1	2	2	1	9	1					550	1	36	21	20
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
33577	33577	9/18/92	9/23/92		3000		15-40	2	2	8	1	2	2	1	9	1					550	1	36	21	20

ALL ELEMENTS APPEAR TO BE NORMAL
NO PROBLEMS INDICATED
RESAMPLE AT A NORMAL INTERVAL

BELOW ARE YOUR PREVIOUS RESULTS

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
CUMMIN	TRUCK	PEPSI COLA	MOSCOW, ID.

OWNER UNIT NO.	COMPARTMENT
PEPSI	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
54410	54410	8/23/93	8/26/93				15-40	2	2	15	1	3	1	1	10	1					40				
ALL ELEMENTS APPEAR TO BE NORMAL THERE ARE NO PROBLEMS INDICATED RESAMPLE AT NEXT NORMAL INTERVAL																									
BELOW ARE YOUR PREVIOUS RESULTS																									

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UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	JOB SITE
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/MILES ON UNIT	HRS/MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZIN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFER % ALLOWABLE	% ALLOWABLE NITRATION
THESE ARE YOUR CURRENT RESULTS																									
68830	68830	3/25/94	3/30/94		58172	4823	15-40	1	1	7	1	3	2	1	4	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
BELOW ARE YOUR PREVIOUS RESULTS																									
62977	62977	1/03/94	1/07/94		53342	4369	15-40	1	1	6	1	2	2	1	2	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
58422	58422	10/19/93	10/25/93		48972	4662	15-40	3	2	9	1	3	2	1	5	1					40				
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
46557	46557	4/22/93	4/27/93			3831	15-40	1	1	9	1	2	1	1	10	1					500	1	17	19	19
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
36036	36036	11/01/92	11/04/92			2995	15-40	1	1	6	1	1	1	1	6	1					525	1	14	16	9
ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																									
33577	33577	9/18/92	9/23/92		3000		15-40	2	3	8	1	2	2	1	9	1					550	1	34	21	20
ALL ELEMENTS APPEAR TO BE NORMAL NO PROBLEMS INDICATED RESAMPLE AT A NORMAL INTERVAL																									

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
72292	72292	5/06/94	5/11/94		61423	3309	15-40	1	1	6	1	3	2	1	8	1					40				
THESE ARE YOUR CURRENT RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
68830	68830	3/25/94	3/30/94		58172	4823	15-40	1	1	7	1	3	2	1	4	1					40				
THESE ARE YOUR PREVIOUS RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
62977	62977	1/03/94	1/07/94		53342	4369	15-40	1	1	6	1	2	2	1	2	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
58422	58422	10/19/93	10/25/93		48972	4662	15-40	3	2	9	1	3	2	1	5	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
46557	46557	4/22/93	4/27/93			3831	15-40	1	1	9	1	2	1	1	10	1					500	1	17	19	19
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
36036	36036	11/01/92	11/04/92			2995	15-40	1	1	6	1	1	1	1	6	1					525	1	14	16	9
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
AG. ENGINEERING LAB

ATTN: DARYL REECE
MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN 2123		MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
77159	77159	7/08/94	7/14/94		66550	5225	15-40	1	1	6	1	2	2	1	3	1					40				
THESE ARE YOUR CURRENT RESULTS	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
72292	72292	5/06/94	5/11/94		61423	3309	15-40	1	1	6	1	3	2	1	8	1					40				
THESE ARE YOUR PREVIOUS RESULTS	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
68830	68830	3/25/94	3/30/94		58172	4823	15-40	1	1	7	1	3	2	1	4	1					40				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
62977	62977	1/03/94	1/07/94		53343	4369	15-40	1	1	6	1	3	2	1	3	1					40				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
58422	58422	10/19/93	10/25/93		48973	4663	15-40	3	3	9	1	3	2	1	5	1					40				
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								
46557	46557	4/22/93	4/27/93			3831	15-40	1	1	9	1	2	1	1	10	1					500	1	17	19	19
	ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																								

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
82845	82845	9/15/94	9/22/94		72326	5775	15-40	1	1	9	1	3	2	1	3	1					40				
THESE ARE YOUR CURRENT RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
77159	77159	7/08/94	7/14/94		66550	5225	15-40	1	1	6	1	2	2	1	3	1					40				
THESE ARE YOUR PREVIOUS RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
72292	72292	5/06/94	5/11/94		61423	3309	15-40	1	1	6	1	3	2	1	8	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
68830	68830	3/25/94	3/30/94		58172	4823	15-40	1	1	7	1	3	2	1	4	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
62977	62977	1/03/94	1/07/94		53342	4369	15-40	1	1	6	1	2	2	1	2	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
58422	58422	10/19/93	10/25/93		48972	4662	15-40	3	2	9	1	3	2	1	5	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
1-3	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

								WEAR METALS ARE REPORTED IN PARTS PER MILLION										PHYSICAL TESTS				INFRARED			
LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
89320	89320	12/05/94	12/09/94		78533	6205	15-40	2	1	5	1	1	2	1	1	1					40				
THESE ARE YOUR CURRENT RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
82845	82845	9/15/94	9/22/94		72326	5775	15-40	1	1	9	1	3	2	1	3	1					40				
THESE ARE YOUR PREVIOUS RESULTS				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
77159	77159	7/08/94	7/14/94		66550	5225	15-40	1	1	6	1	2	2	1	3	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
72292	72292	5/06/94	5/11/94		61423	3309	15-40	1	1	6	1	3	2	1	8	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
68830	68830	3/25/94	3/30/94		58172	4823	15-40	1	1	7	1	3	2	1	4	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					
62977	62977	1/03/94	1/07/94		53342	4369	15-40	1	1	6	1	2	2	1	2	1					40				
				ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																					

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SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	2123	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
123	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	WEAR METALS ARE REPORTED IN PARTS PER MILLION: LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	PHYSICAL TESTS: FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	INFRARED: SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
94227	94227	1/27/95	2/02/95		82100	3565	15-40	1	1	6	1	3	3	1	6	1					30				
THESE ARE YOUR CURRENT RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
89320	89320	12/05/94	12/09/94		78533	6205	15-40	2	1	5	1	1	2	1	1	1					40				
THESE ARE YOUR PREVIOUS RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
82845	82845	9/15/94	9/22/94		72326	5775	15-40	1	1	9	1	3	2	1	3	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
77159	77159	7/08/94	7/14/94		66550	5225	15-40	1	1	6	1	2	2	1	3	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
72292	72292	5/06/94	5/11/94		61423	3309	15-40	1	1	6	1	3	2	1	8	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
68830	68830	3/25/94	3/30/94		58172	4823	15-40	1	1	7	1	3	2	1	4	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						

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Western States **CAT**

General Office
P.O. Box 38
Boise, ID 83707-0038
208/888-CATS
FAX 208-888-3932

SCHEDULED OIL SAMPLING WEAR ANALYSIS REPORT

UNIVERSITY OF IDAHO
ATTN: DARYL REECE
AG. ENGINEERING LAB

MOSCOW ID 83843

MAKE	MODEL	SERIAL NUMBER	MISC. INFO.
DODGE	CUMMIN	2122	MOSCOW, ID

OWNER UNIT NO.	COMPARTMENT
[illegible]	DIESEL ENGINE

PHYSICAL TESTS: 1 = ACCEPTABLE 2 = TRACE 3 = REPORTABLE 4 = CRITICAL

WEAR METALS ARE REPORTED IN PARTS PER MILLION | PHYSICAL TESTS | INFRARED

LAB CONTROL NO.	SAMPLE SHEET NO.	DATE SAMPLE TAKEN	DATE SAMPLE PROCESSED	MAKE UP OF OIL ADDED IN QT./GAL.	HRS/ MILES ON UNIT	HRS/ MILES ON OIL	SAE OF OIL IN USE	LEAD PB	COPPER CU	IRON FE	CHROME CR	ALUMINUM AL	SILICON SI	TIN SN	SODIUM NA	MOLYBDENUM MO	ZINC ZN	FUEL DILUTION	ANTI-FREEZE	WATER	SAE OF SAMPLE (VISCOSITY)	SOOT % ALLOWABLE	OXIDATION % ALLOWABLE	SULFUR % ALLOWABLE	% ALLOWABLE NITRATION
1099	1099	4/07/95	4/17/95		87787	5600	15-40	1	2	9	1	4	4	1	4	1					40				
THESE ARE YOUR CURRENT RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
94227	94227	1/27/95	2/02/95		82100	3565	15-40	1	1	6	1	3	3	1	6	1					30				
THESE ARE YOUR PREVIOUS RESULTS			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
89320	89320	12/05/94	12/09/94		78533	6205	15-40	2	1	5	1	1	2	1	1	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
82845	82845	9/15/94	9/22/94		72326	5775	15-40	1	1	9	1	3	2	1	3	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
77159	77159	7/08/94	7/14/94		66550	5225	15-40	1	1	6	1	2	2	1	3	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						
72292	72292	5/06/94	5/11/94		61423	3309	15-40	1	1	6	1	3	2	1	8	1					40				
			ALL WEAR ELEMENTS ARE AT ACCEPTABLE LEVELS. RESAMPLE AT NEXT NORMAL INTERVAL.																						

LubeWatch™
Maintenance Management System

(800) LUBE-808

11607 EAST TRENT AVENUE, SPOKANE, WASHINGTON 99206 (509) 921-9909, FAX (509) 921-9910

Chevron
Global Lubricants and Technology Marketing

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: DODGE-RAM-250
Condition: NORMAL
Analyst : RGT

MAKE: DODGE 92 MODEL: RAM 250
UNIT SERIAL NO:. IB6KE26CINS542134 (#123)

OIL BRAND: CHEVRON
OIL TYPE: 15W40
FUEL TYPE: DIESEL

NO. COPIES: 2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS (VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT) / PHYSICAL PROPERTY DATA

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
6490	03/05/96 03/08/96	114300 ?	31	1	9	3	0	5	0	0	0	1	133	10	47	2238	0	1136	1316	0	0	0	0	N/A	<1	N/A	14.05	0	N/A	NEG
17332	06/14/96 06/19/96	3331 91886	5	0	3	1	0	1	0	0	0	1	147	9	16	2161	0	1027	1195	0	0	0	0	N/A	<1	N/A	13.47	0	N/A	NEG
21325	07/29/96 07/31/96	126311 ?	35	2	12	3	0	5	0	0	0	1	104	4	27	2043	0	1019	1207	0	0	0	0	N/A	<1	N/A	14.88	0	N/A	NEG
23408	08/13/96 08/20/96	? 95908	6	0	3	1	0	1	0	0	0	2	147	3	16	2191	0	1065	1204	0	0	0	0	N/A	<1	N/A	14.55	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
6490	0.2	5.4	40
17332	0.2	5.5	40
21325	0.6	4.8	40
23408	0.2	5.2	40

PARTICLE COUNT RESULTS

LAB#	ANALYSIS RECOMMENDATIONS
6490	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
17332	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
21325	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
23408	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

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11607 EAST TRENT AVENUE, SPOKANE, WASHINGTON 99206 (509) 921-9909, FAX (509) 921-9910

Chevron Lubricants

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: DODGE-RAM-250 OIL BRAND: CHEVRON

Condition: NORMAL MAKE: DODGE MODEL: RAM 250 OIL TYPE: DELO

Analyst : RGT UNIT SERIAL NO:. IB6KE26CINS542134 FUEL TYPE: DIESEL NO. COPIES: 2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS (VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT) / PHYSICAL PROPERTY DATA

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
6490	03/05/96	114300	31	1	9	3	0	5	0	0	0	1	133	10	47	2238	0	1136	1316	0	0	0	0	N/A	<1	N/A	14.05	0	N/A	NEG
	03/08/96	?																												
17332	06/14/96	3331	5	0	3	1	0	1	0	0	0	1	147	9	16	2161	0	1027	1195	0	0	0	0	N/A	<1	N/A	13.47	0	N/A	NEG
	06/19/96	91886																												

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
6490	0.2	5.4	40
17332	0.2	5.5	40

PARTICLE COUNT RESULTS

LAB# ANALYSIS RECOMMENDATIONS

LAB# ANALYSIS RECOMMENDATIONS

6490 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

17332 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

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Chevron Lubricants

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: DODGE-RAM-250 OIL BRAND: ?

Condition: NORMAL MAKE: DODGE MODEL: RAM 250 OIL TYPE: 15W40

Analyst : RGT UNIT SERIAL NO:. IB6KE26CINS542134 FUEL TYPE: DIESEL NO. COPIES: 2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS* (VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT)

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
6490	03/05/96 03/08/96	114300 ?	31	1	9	3	0	5	0	0	0	1	133	10	47	2238	0	1136	1316	0	0	0	0

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
N/A	<1	N/A	14.05	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE							
6490	0.2	5.4	40							

PARTICLE COUNT RESULTS

LAB# ANALYSIS RECOMMENDATIONS

LAB# ANALYSIS RECOMMENDATIONS

6490 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

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Chevron Lubricants

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: DODGE-RAM-250
Condition: NORMAL
Analyst : RGT

MAKE: DODGE 92 MODEL: RAM 250
UNIT SERIAL NO:. IB6KE26CINS542134 (#123)

OIL BRAND: CHEVRON
OIL TYPE: 15W40
FUEL TYPE: DIESEL

NO. COPIES: 2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS (VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT)

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
6490	03/05/96	114300	31	1	9	3	0	5	0	0	0	1	133	10	47	2238	0	1136	1316	0	0	0	0
	03/08/96	?																					
17332	06/14/96	3331	5	0	3	1	0	1	0	0	0	1	147	9	16	2161	0	1027	1195	0	0	0	0
	06/19/96	91886																					
21325	07/29/96	126311	35	2	12	3	0	5	0	0	0	1	104	4	27	2043	0	1019	1207	0	0	0	0
	07/31/96	?																					

PHYSICAL PROPERTY DATA

FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
N/A	<1	N/A	14.05	0	N/A	NEG
N/A	<1	N/A	13.47	0	N/A	NEG
N/A	<1	N/A	14.88	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
6490	0.2	5.4	40
17332	0.2	5.5	40
21325	0.6	4.8	40

PARTICLE COUNT RESULTS

LAB#	ANALYSIS RECOMMENDATIONS
6490	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
17332	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.
21325	RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

CTC CV-100 7/18/95

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11607 EAST TRENT AVENUE, SPOKANE, WASHINGTON 99206 (509) 921-9909, FAX (509) 921-9910

Chevron Lubricants

DESCRIPTION: ENGINE

CUSTOMER NO.: 19562 UNIT NO.: CLP
Condition: ABNORMAL
Analyst : RGT

MAKE: DODGE MODEL: RAM 2500
UNIT SERIAL NO:.

OIL BRAND: CHEVRON
OIL TYPE: DELO 15W40
FUEL TYPE: DIESEL NO. COPIES: 2

SAMPLE DATA / SPECTROCHEMICAL ANALYSIS (VALUES EXPRESSED IN PARTS PER MILLION (PPM) BY WEIGHT)

LAB#	DATE TAKEN/ TESTED	HRS/MI OIL UNIT	IRON	CHROMIUM	LEAD	COPPER	TIN	ALUMINUM	NICKEL	SILVER	MANGANESE	SILICON	BORON	SODIUM	MAGNESIUM	CALCIUM	BARIUM	PHOSPHORUS	ZINC	MOLYBDENUM	TITANIUM	VANADIUM	POTASSIUM
20353	08/29/95 09/01/95	3384 4955	26	2	3	12	0	5	0	0	0	12	107	23	61	1930	0	1036	1218	15	0	0	0
29733	11/11/95 11/14/95	3739 8694	20	1	2	5	0	5	0	0	0	6	120	10	52	2066	0	1031	1284	3	0	0	0
22356	08/03/96 08/09/96	4027 12722	183 ^^^^	6	5	5	0	7	0	0	0	9	122	3	50	2172	0	1032	1210	0	0	0	0

PHYSICAL PROPERTY DATA

LAB#	FLASH	FUEL % Vol	VIS 40° C cSt	VIS 100° C cSt	WATER % Vol	SOLIDS % Vol	GLYCOL
20353	N/A	<1	N/A	12.50	0	N/A	NEG
29733	N/A	<1	N/A	12.53	0	N/A	NEG
22356	N/A	<1	N/A	12.52	0	N/A	NEG

ADDITIONAL CUSTOMER TESTS

LAB#	F-SOOT	TBN	SAE
20353	0.1	5.8	40
29733	0.1	5.6	40
22356	0.5	5.5	40

PARTICLE COUNT RESULTS

LAB# ANALYSIS RECOMMENDATIONS

20353 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

LAB# ANALYSIS RECOMMENDATIONS

29733 RESULTS OF TESTS PERFORMED INDICATE NO CORRECTIVE ACTION REQUIRED.

22356 NOTE: IRON LEVEL APPEARS TO BE HIGH.
RECOMMEND CHANGE LUBE OIL AND LUBE OIL FILTER, IF NOT ALREADY DONE.
RECOMMEND RESAMPLE TO CHECK WEAR TREND.

DARYL REECE
UNIVERSITY OF IDAHO
AEL 81
MOSCOW, ID 83844-2040

CTC CV-100 7/18/95

Appendix C

Log Sheets Compiled During the Vehicle Tests

Department of Agricultural Engineering
University of Idaho
Vehicle Use and Mileage Report

1992 DODGE
X59

DATE	HOURS	SPEEDOMETER READING START	END	No. of MILES	GAL. OF 2-D FUEL	RME (in)	GALS RME USED	RME Fuel Fill (in)	FUEL MILEAGE	PERCENT RME USED	DATE	COMMENTS
July 7	0		85	0	FULL						July 7	NEW
July 24	0.3	85	301	216	10.9				19.82		July 24	
July 24	6.2	301	667	366	18.43				19.86		July 24	
July 25	8.9	667	824	157							July 25	
July 25	12	824	1009	185	15.9				21.51		July 25	
July 25	18	1009	1382	373	20.2				18.47		July 25	
July 30	24.4	1382	1637	255	9.7				26.29		July 30	Dyno Test
Aug 13	33.6	1637	1976	339	15.4	18.75			22.01		Aug 13	Methyl Ester Tank Fill
Oct 13	103.7	1976	5413	3437	139.94	10.75	24.9	18.5	20.85	15.12	Aug 19	Pickup Left in Boise
Nov 9	160	5413	8167	2754	103.59	10.68	24.4	18.5	21.52	19.05		Filled with RME
Nov 24	193.7	8167	9904	1737	79.535	14.875	11.3	17.625	19.12	12.44		
Jan 4	212.7	9904	10605	701	31.4	17.5	0.4	18.1875	22.05	1.23		fill up
Feb 9	251.7	10605	12320	1715	70.89	14	13.1	18.5	20.43	15.55		
April 2	321.1	12320	15695	3375	159.106	13.25	16.4	17.75	19.23	9.33		
May 29	402	15695	19674	3979	146.43	5.1875	39.2	18.5	21.44	21.10		
June 24	457.8	19674	22391	2717	85.56	4.375	44.0	16.875	20.97	33.97		
July 15	496.5	22391	24538	2147	58.53	2.5	44.8	18.5	20.78	43.36		
Aug 16	530.6	24538	26079	1541	32.63	3.75	46.0	17.75	19.60	58.49		
	551.3	26079	26849	770	15.4	12.375	16.8	17.25	23.95	52.10		
Oct 18	601.7	26849	29327	2478	53.49	3.25	43.6	18.5	25.51	44.93		
Nov 9	616.4	29327	30034	707	35	13	17.1	18.5	13.56	32.88		
Nov 15	635.3	30034	30992	958	30.4	12.375	19.1	17.375	19.36	38.57		
Jan 7	674.2	30992	32887	1895	72.48	7.5	30.8	18.5	18.35	29.81		
Feb 6	714.2	32887	34745	1858	62.2	10.125	26.1	18.75	21.0	29.56		
Feb 18	743.5	34745	36215	1470	54.15	13	17.9	18.25	20.4	24.87		
March 11	774	36215	37673	1458	44.95	10.5	24.2	18.5	21.1	34.95		
March 16	800.3	37673	38820	1147	31.42	13.375	16.0	18.5	24.2	33.70		
March 23	820	38820	39843	1023	33.37	13	17.1	18.125	20.3	33.94		
April 4	831.9	39843	40450	607	18.28	15.25	9.0	18.5	22.3	32.90		
April 29	872.9	40450	42532	2082	64.14	8.6875	30.6	18.5	22.0	32.29		
May 23	914.8	42532	44590	2058	65 06	7.75	33.5	17.25	20.9	33.99		
June 9	953.6	44590	46472	1882	59.04	8.5	27.3	18.5	21.8	31.60		
Aug 15	1014.5	46472	49318	2846	81.558	4.5	43.6	18	22.7	34.85		
Sept 29	1042.6	49318	50602	1284	37.056	5.875	37.8	16.75	17.2	50.49		
Oct 25	1080.2	50602	52550	1948	50.43	5.125	36.2	16	22.5	41.81		
Nov 7	1105.2	52550	53685	1135	42.441	11.5	14.0	16	20.1	24.84		
Jan 23	1152.2	53685	55772	2087	77.555	9.5	20.3	16.5	21.3	20.71		
Feb 15	1202	55772	58304	2532	81.85	6.5	31.2	16.875	22.4	27.58		
March 24	1267	58304	61017	2713	98.04	7.5625	29.0	16.75	21.4	22.84		
April 21	1291.3	61017	62785	1768	60.07	9.5625	22.4	18.125	21.4	27.16		
June 5	1357.8	62785	66339	3554	121.7	3.6875	45.0	16.75	21.3	26.99		
June 19	1387 1	66339	67836	1497	24.016	9	24.2	17.25	31.1	50.15		
Aug 4	1442	67836	70380	2544	85.81	6.875	32.3	16.625	21.5	27.37		
Sept 11	1492.5	70380	73086	2706	95 51	6.5	31.6	14.875	21.3	24.84		
Aug 25	1515.9	73086	74359	1273	28.703	4.25	33.1	16.8125	20.6	53.57		
Oct 3	1542.2	74359	75642	1283	44.13	12.25	14.2	17.625	22.0	24.37		
Dec 5	1626 4	75642	79789	4147	131.26	3.375	44.4	18	23.6	25.28		
Feb 7	1684	79789	82617	2828	103.433	7.5	32.7	17	20.8	24.04		
March 8	1729	82617	84913	2296	93.96	8.5	26.5	18	19.1	21.99		
April 17	1779 6	84913	87609	2696	109 103	6.875	34.7	13.5	18.8	24.12		
May 19	1820 4	87609	89634	2025	80.71	4.25	28.8	17.4375	18.5	26.32		
July 3	1883.9	89634	92856	3222	138.31	4.25	41.1	17.5	18.0	22.91		
July 31		ERR	94920	2064	65.33	11.165	19.7	18.1875		23.21		
Aug. 19	1968.4	ERR	96496	1576	63.53	7.1875	34.3	17		35.05		
Sept. 24	2020	ERR	99385	2889	101.54	5.1875	36.8	16		26.61		
	2023 7	99385	99956	571	19.78							
	2024.2	99956	100179	223								
	2028.3	100179	100186	7								
		100186	100453	267	19.3							

Total Miles	97748
Total Diesel	3363.0
Total RME	1307.4
Percent RME	28.0
Fuel Mileage	20.9
Total Hours	1986.4
Miles Per Hour	49.209

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)		DESTINATION	DRIVER (Name not initials)	FUEL						OIL Chevron Delco 400 15W-40 ONLY
							Diesel Fillup				RME Fillup		
							Station	$	Gal	RME (In)	Inches Before	Inches After	
	23.4	237	056										
	24.4	1637	056	K262		Daryl Reece			9.7		55 gallons		Changed
	33.6	1976	056		Boise	Daryl Reece			15.4				
8/19	36.5	2124	056		Weiser	Scott King							
8/20	36.7	2126	056		Garden City	A. Fleischman							
8/21	37.1	2132	056		Boise	A. Galenato							
8/26		2361 *	056		Kimberly	A. Galenato	Mt-Home	19.63	18.33	18 1/8			
8/26	42.3	2410	056		Kimberly	A. Galenato				16 1/4			
9/4/92	42.7	2425	056		TEC Meridian	G. Fleischman							
9/4/92	43.6	2448	056		EAGLE	J. Miller							
9/8/92	50.8	2862	056		PORTLAND	R. STERLING	TROUTDALE OR	24.32	21.51	~~[illegible]~~	17 1/4		
9/10/92	59.1	3315	056		BOISE	R. STERLING	ITD BOISE	—	19.50	17 3/8			
9/14/92			056							17"			
9/17/92	61.5	3421	056		MURPHY	J. Miller							
9/18/92	62.5	3447	056		EAGLE	J. Miller							
9/25/92	70.0	3738	056		McCall	B. Gore	Phillips, Boise	26.9	15.0	16"			
9/30/92	77.9	4166	056		DOWNEY	J. Miller	FLAGS WEST	17.99	17.65	14 7/8"			
10/2/92	84.8	4488	056		BOISE	J. Miller	SINCLAIR BOISE	14.57	11.39	14 5/8"			
10/5/92	85.1	4496	056		Western States Cat	G. Fleischman							Changed
10/6/92	90.5	4822	056		REXBURG	B. SCHOLOR							
10/7/92	93.1	4912	056		POCATELLO	" "	PHILLIPS 66	23.03	17.25	9 5/8"			

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. *Beginning of program.

9-4-92 Gas pedal buzzes at 65 mph.

9-16-92 Apparently the truck was not using RME fuel or was using very little so Daryl Reece drove down from [illegible] to fix the problem. It turned out the needle valve that regulates the flow of RME fuel on the RME fuel line was plugged. Daryl thought it was some dirt or something from the new tank and lines.

9-25 No problems w/operation. Note that windshield cracked before this trip

10-23 Clutch must be all the way out to engage. Perhaps it needs adjustment.

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup — Station	$	Gal	RME (In)	RME Fillup — Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
10/7/92	93.7	4921	056	Pocatello	B. Scholer							
10/8/92	95.3	5092	056	Pocatello	" "							
10/9/92	102.5	5391	056	Boise	" "							
10/13/92	102.8	5393	056	Nu-Look	G. Fleischman	~~[illegible] Boise~~						
10/13/92	103.7	5413	056	NCAT meeting ID-K	Peterson Reece G. Fleischman						~~18.5~~	
10/13/92	103.7	5413	056		G. Fleischman					$10\frac{3}{4}$"	~~18.5~~	
10/14/92	103.7		056	Seattle	R. Sterling	Stinker Boise	24^{50}	19.31	~~18.5~~			
10/22/92	112.8	5931	056			Texaco Issaquah WA	22^{00}	17.47	$17\frac{3}{8}$			
10/23/92	121.5	6430	056			Stinker Boise	24^{00}	18.62	16.0			
10-23-92		6472	056	Local ~~NASLIKA~~	Gleason							
10-27-92	122.9	6485	056	Local ASCS	Scholer				$14\frac{3}{4}$			
10-28-92	128.0	6726	056	Kamiah	S. Stultz	CHECK RME ONLY	—	—	$15\frac{1}{2}$			
10-30-92	133.6	6967	056	Kamiah to ~~Nu-Look~~ (Boise)	S. Stultz	Nu-Look	27^{80}	19.9	$14\frac{5}{8}$			
11-2-92	143.9	7500	056	Seattle	S. King	Texaco-Bellevue	31^{70}	23.5	$13\frac{5}{8}$			
11-5-92	157.6	8107	056	Boise	S. King	Stinker—	31^{69}	24.2	$10\frac{7}{8}$			
11-6-92	159.5	8159	056	Boise	S. King	—	—	—	—			
11-9-92	160.0	8167	056	Local	Fleischman					10[illegible]*	18.5	Oil changed
11-13-92	164.1	8395	056	Mt Home/Fairfield	Stultz	Nu-Look (Boise)	16^{70}	12.0	18.0			
11-18-92	174.2	8848	056	~~Pocatello~~/Bliss (side)	Stultz	Stinker (Bliss)	27.02	20.65	$17\frac{1}{4}$			
11-20-92	178.6	9033	056	Idaho City	G. Fleischman	Stinker (Boise)	10.61	8.1	$16\frac{3}{4}$			
11-23-92	186.9	9485	056	Troutdale Burns Brothers	"	Burns Brothers	25.20	20.175	16			

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. *Beginning of program.

11-9-92 ~ *-Lower level calculated from 10-5-92 measure

11-18-92 ~ The fuel pump indicator lights came on only once between Bliss and Boise

11-24-92 ~ Chip in windshield - upper left corner

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)		DESTINATION	DRIVER (Name not initials)	FUEL						OIL Chevron Delco 400 15W-40 ONLY
							Diesel Fillup				RME Fillup		
							Station	$	Gal	RME (In)	Inches Before	Inches After	
11-24-92	193.7	9904*	056		Portland	Gerald Fleischman	Stinker-Orchard	24.35	18.6	15	14 1/2	17 5/8	
12-7-92	194.2	9908	056		Les ~~Schwab~~ Schwabb	Gerald Fleischman							
12-7-92	205.5	10356	056		Moscow	CL Peterson			22.3	17 1/2			
12-18-92	211.2	10584	056	K216	Spokane	D Reece							
1-4-93	212.7	10605	056	K216	local	"			9.1	18 3/16		18 3/16	
1-4-93	213.7	10637	056	K216	Lewiston	"							
1-5-93	220.0	10907*	056		Lewiston-Boise	G Fleischman	Stinker-Orchard	12.63	10.9	18 1/4"			
1-5-93			056		Burley	R. Sterling							
1-7-93	229.3	11298*	056		Boise	"	Stinker-Orchard	19.10	16.48	16 1/2			
1-8-93	229.8	11307	056		Western States Cat	G Fleischman							Oil Changed
1-12-93	235.5	11588*	056		TWIN FALLS	R. Sterling	Stinker Orchard	13.91	11.91	15 7/8			
1-15-93	237.7	11659	056		Caldwell	S. King	—						
1-22-93	244.4	11946*	056		Pocatello	R. Sterling	Texaco Pocatello	21.30	17.6	15 1/4			
1-22-93	248.3	12181*	056		Poky - Boise	R. Sterling	Stinker-Orchard	16.20	14.0	15 1/8			
2-1-93	250.5	22267	056		Idaho City	S. Fleischman							
2-4-93	251.7	12320	056		CALDWELL	R. Sterling							
2-9-93	251.7	12320	056			G. Fleischman					14"	18.5	
2-16-93	254.9	12454*	056		Wells NV	Miller	Sinclair T.F	15.00	12.5	18.0"			
2-17-93	256.0	12562	056		TWIN FALLS	Scholer							
2-20-93	261.1	12707*	056		Twin Falls	G. Fleischman	Amoco	13.45	11.22	17.5"			
2-21-93	267.6	13086*	056		Butte	Fleischman	Frontier Mustang Exxon	9.59	10.34	17.5			

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. * Beginning of program.

12-1-92 New studded snow tires installed on rear
12-1-9 Dynoed Pickup, changed fuel filter
1-5-93 Noticed when cold 18° outside and first starting - fuel pump lights are off for only 2 seconds. As it warms up this lengthens to the normal of over 2 minutes at cruise speed.
2-24-93 The RME Tank read 18.5°F this morning. It was 22°F yesterday. The outside temperature was -8°F both nights.

DATE	ENDING HOURS	ENDING MILEAGE (Indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup Station	$	Gal	RME (In)	RME Fillup Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
2-24-93	277.0	13492*	056		G. Fleischman	Cowboy-Cutback	25.00	21.39	17"			
2-25-93	282.3	13745*	056		G. Fleischman	Stinker-Orchard Boise	13.39	11.556	16 5/8"			
2-26-93	283.4	13794	056	Caldwell, Return	S. King	—	—	-				
3-9-93	291.8	14234*	056	Portland	G. Fleischman	Chevron, Portland	29.85	21.8	15 7/8			
3-11-93	301.4	14759*	056	Portland	G. Fleischman	Stinker-orchard Boise	28.52	23.59	15"			
3-12-93	301.8	14768	056	Western States Cat	G. Fleischman			~~28.62~~				*Oil changed
3-18-93	306.3	15,031	056	Twin Falls/Return	S. King	Stinker - overland	15.12	12.5	14 1/4"			
3-31-93	316.7	15,550	056	~~Spokane~~	G. Fleischman	Spokane-Exxon	26.66	20.21	13.5			
4-2-93	321.1	15695	056	Moscow				8.0	13 1/4	13 1/4	17 3/4	filled both DZ & RME
4-5-93	327.8	16011	056	Boise	G. Fleischman	Stinker-Orchard	12.28	10.5	17"			
	328.5	16018	056									
4-7-93	328.9	16027	056	Local	S. King	—						Changed
4-8-93	330.9	16,107	056	Caldwell	R Reece							to summer
4/13/93	339.5	16625	056	SEATTLE	R. STERLING	TEXACO SEATTLE	28.35	22.00	15 1/4			tires
4/16/93	348.6	17148	056	" Return	S. King	—						
4/19/93	350.0	17162	056			Stinker Orchard	24.41	20.055	13 1/4			
4/21/93	351.0	17177	056	Local	S. King							
4/24/93	360.3	17728	056	~~Seattle~~ Pasco	S. King	Texaco - Ontario	27.00	22.0	11 1/2			
"	361.3	17783	056	Return	"	———						
4/26/93	361.5	17788	056		G Fleischman							*Oil Changed
5/5/93	366.3	18005*	056	Shoshone / Return Mt. Home	T. Luke	Texaco - MT. Home	12.64	10.28	10 1/2			

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. * Beginning of program.

3-12-93	Kurt at Western States Cat said the engine coolant level was very low. He had the cooling system tested for leaks, but he didn't find any. He filled the coolant to its proper level.
4-16-93	Strange loss of power for about 5 minutes.

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup: Station	$	Gal	RME (In)	RME Fillup: Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
5/5/93	367.2	18051	056	Return from Shoshone	T. Luke	—						
5/13/93	377.3	18401	056	BOISE	J. MILLER	EXXON; KENNEWICK	19.55	15.65	9"			
5/14/93	379.5	18707	056	BOISE	J. MILLER	STINKER; BOISE	13.25	11.0	8.5"			
5/14/93	381.2	18769	056	Emmett	S. King	—						
5/20/93	392.0	19299	056	Moscow	S. King	Exxon	27.18	20.0	6.75"			
5/20/93	392.7	19311	056	Moscow Airport	S. King	—	–	–	–			
5-	396.7	19427	056	Potlatch	D. Reece							
5-29	402.0	19674	056					15.0		5 3/16	18.5	
5-31	408.2	19934	056	Pullman	D. Reece			8.6				
6-6	414.2	20736	056	Lewiston	D. Reece			12.8				
6-7	421.2	20544	056	Boise	D. Reece							oil changed
6/9	425.7	20766	056	Boise	J. MILLER	TEXACO-Mt HOME			NO MEAS. STICK			
			056				22.00	18.0				
6/14	428.5	20881	056	CALDWELL	K Reece							
6/14	428.9	20887	056	Local	G. Fleischman							
6/16	434.9	21166	056	Boise	S King	ITD-Lewiston	—	10.0				
6/17	440.3	21431	056	Boise	G. Fleischman	ITD Boise		7.2	10.5"			
6-23	450.0	21935	056	BOISE	B. SCHOLER	SPOKANE WA	19.30	14.2				
6-24	457.8	22391	056	LOCAL	B. Scholer	STINKER BOISE	18.00	14.76	4 3/8"			
6-24	457.9	22392	056	Fill RME	G. Fleischman					4 3/8"	16 1/8"	
6-25	463.1	22667	056	Twin Falls	C Fritschle							

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. * Beginning of program.

5/12 ~~&~~ 5/13 MAJOR LOSS OF POWER; REMAINING NOW INSTEAD OF COMING & GOING; BLUISH EXHAUST

ADDED INJECTOR CLEANER/WATER DISPERSANT DURING 5/13 FILL-UP.

5/13 18439 MI CHANGED FUEL FILTER; PROBLEM CURED, POWER BACK

DATE	ENDING HOURS	ENDING MILEAGE (Indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup Station	$	Gal	RME (In)	RME Fillup Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
6-30	468.2	22937	056 —	Twin Falls	R. McCarthy				14"			
7-1	468.3	22938*	056			Stinker-Orchard Boise	18.00	14.76	14"			
7-6			056	PORTLAND	R. STERLING							
7-7	477.8	23498*	056		"	'76 Biggs OR	25.50	17.5	11 1/4			
7-7	483.1	23827	056		"				9"			
7-8-93	~~453~~.2	23828*	056		G. Fleischman	Stinker Orchard Boise	11.18	9.17	9 3/8"			
7-9-93	483.5	23833	056	Western States Cat	G Fleischman							oil changed
7-9-93	488.0	24103	056	Twin Falls	M Minicucci				7 1/4"			
7-13-93		24261*	056	Burley / ~~Phillips~~ 66	G. Galinato	Phillips 66 - Burley	20.51	17.1	4 3/8	~~[illegible]~~		
7-14-93	494.2	24441	056									
7-15-93	496.5	24,638	056	Wilder	G. Galinato							
7-15-93	496.5	24,538	056		G. Fleischman				~~[illegible]~~	2 1/2"	8 7/8"	
7-21-93	497.1	24556	056	Local	~~G. Fleschman~~							
7-22-93	499.0	24614	056	Middleton	S King	—						
7-23-93	499.0	24616	056	Boise	G. Fleischman	Nu-Look	5.00	3.8				
7/28/93		25,173*	056		G. Galinato	Seattle	8.26	6.95	7 7/8		~~[illegible]~~	
7/30/93	521.4	25,728	056	Seattle, Walla Walla	G. Galinato							
8/2/93	521.5	25 729*	056	~~Stinker Orchard~~ Stinker	G Fleischman		9.61	7.884	4 1/4"			
8/7/93		25734*	056	Local	Seifert							
			056									
	*REM light stayed on all the time		056									

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc.) Beginning of program.

7/13/93 - Car wash @ Nu-Look, Boise

7/13/93 - Cruise control does not work properly. It needs several push before engaging properly. GMG O.K. GMG 7/28/93

7/13/93 - Measuring stick is missing. Could not measure biodiesel fuel tank after filling up with reg. diesel. GMG (Bought alum. meas. stick) ~~No~~ measurement made over the bump - stick it to side of hole.

7/15/93 - Diesel Fuel Tank Gage does not appear to be working

7/20/93 - upper float stuck, RME pump continues to run - Daryl fixed it today

7/30/93 - appears to have very fast consumption of RME. GMG

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup Station	$	Gal	RME (in)	RME Fillup Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
8-16	530.6	26079	056	Moscow	Daryl Reece	U of I		14.0	3 3/4		17 3/4	
8-27	532.4	26155	056	Steptoe	CLP							
8-30	536.5	26305	056	Orofino	DR							
	549.4	26776	056						12 3/8			
	551.3	26849	056	Lewiston	DR			15.4	12 3/8	12 3/8	18 1/4	
9-27	556.6	27076	056	Spokane	DR							
10-1 ~~9-22~~-93	561.7	27285 *	056	Lewiston	Gerald Fleischman	Flying J - Lewiston	11.04	8.84	~~[illegible]~~			
10-4-93	567.8	27597	056		11				13 1/4			
10/6/93	576.1	28001 *	056	IDAHO FALLS	J. MILLER	CHEVRON/REXBURG	30.00	22.4				
10/13/93	589.9	28709 *	056	REXBURG	J. MILLER	TRAVELL PLAZA	34.00	22.25	6 5/8"			
10-15-93	601.7	29326	056	Boise	B. Scholl	OFFICE			3 1/4			
10-18-93	601.7	29327	056	Boise	B. Scholl	office			18 1/2"	3 1/4	18 1/2"	
10-19-93	605.3	29507 *	056	JEROME	B. Scholl	JEROME GAS & OIL	31.52	22.0				
10-22-93	614.2	29974	056	BOISE	B. Scholl	OFFICE			14 3/4"			
10-22-93	614.6	29983	056	Local (Caterpillar)	G. Fleischman							# Changed Oil
10-26-93	615.0	29998 *	056	Local (Stinker)	11	Stinker Orchard	18.3	13.0				
11/5/93	616.4	30034	056	LOCAL	J. MILLER							
11/10/93	616.4	30034	056		G. Fleischman				~~15~~	13.0	18.5	
11/13/93	631.4	30764	056		S. King	Exxon - Pendleton	32.85	23.2	13.5			
11/15/93	635.3	30992	056	Portland	S King	Stinker Boise	10.58	7.2	12 3/8			
11-15-93	635.3	30992	056		G. Fleischman					12 5/8	17 3/8	

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. *Beginning of program.

REPLACE LEFT HEADLAMP @ 29326 = $24.76

11-9 Daryl made adjustments to fuel system 30,027

11-13 RME degrading gasket on fuel tank. Pieces falling into tank.

11-15 Does not cold-idle as well with higher RME ratio.

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup: Station	$	Gal	RME (In)	RME Fillup: Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
11-18	640.6	31271	056	TWIN FALLS + RETURN	SCHOLER	STINKER BOISE	18.00	12.8	15 7/8"	[illegible]		
11-19	640.6	31272	056			↓ ↓	↓	↓	↓			
11-22	645.0	31544	056	Twin Falls	Fleischman	" "	11.66	8.33	4 3/8			
12/7	648.2	31603	056	CALDWELL	J. MILLER							
12/15	653.4	31898	056	Idaho Falls	G. Fleischman	Phillips 66	18.52	13.6				
12/16	664.3	32469	056	Lewiston	G. Fleischman	Flying J	22.61	18.25	9 1/4			
12-17	665.1	32503	056	Moscow	"	U of I		3.25	9 1/2			
12-22	671.1	32733	056	Spokane	DR							cover installed
1-5	672.7	32821	056	Lewiston	DR							oil changed
1-7	674.2	32887	056	"	DR	U of I		16.25		7 1/2	18 1/2	
1-7	679.9	33185	056							16.5	18	
1/13	685.6	33473	056	IDAHO FALLS	B. SCHOLER	TEXACO I.F.	22.0	19.0				
1/20	699.9	34063	056	POCATELLO	J. MILLER	FORDE-JOHNSON	23.50	20.0				
1/28	708.0	34563	056	GRAND VIEW	J. MILLER	TEXACO-MT HOME	17.85	16.4				
1/31	712.0	34689	056	BOISE	J. MILLER	STINKER-BOISE	7.50	6.8		10 3/8		
2/6	714.2	34745	056	CHALLIS	J. MILLER					10 1/8	18 3/4	
2/7	722.9	35224	056	ARCO	J. MILLER	CHALLIS	17.30	14.5				
2/9	730.7	35645	056	TWIN FALLS	R. STERLING	MR GAS SINCLAIR	21.50	18.2				
2/10	733.8	35781	056		R. STERLING							
2/11	733.9	35782	056		G. Fleischman	Stinker Boise	7.00	6.15				
2-15	741.7	36159	056	Moscow	D. Reece	U of I		12.7	13			

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. *Beginning of program.

11-24-93 The truck started but would not keep running this morning. It was taken to Les ~~Sch~~ Schwab to have the snow tires put on. It was left out overnight. It got down to -7°F. It started and ran 2 blocks before stoping. It would not keep idling to warm up. We ~~to~~ towed it back to the office and plugged in the in-line heater. [illegible]

12-2-93 - Replaced the fuel filter and tried method of starting after running out of fuel contained in owner's manual. It still wouldn't start. Had the truck

12-3-93 towed to the Cat truck shop in Boise. Mike bled the air out of the injection lines and it started right up. It appears to be running well now.

12-13-93 Rin No 1 + No 2 diesel at pump in Idaho Falls - Price No 1 $1.35.9 No 2 $1.15.9 I put in No 1 Didn't plug in last night Temp 20°F

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup: Station	$	Gal	RME (In)	RME Fillup: Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
2-18	743.5	36215	056		D. Reece			2.6		13	18 1/4	changed oil
2-21	752.7	36626	056		G. Fleishman				14 5/8"			
2-22	752.7	36627	056		G. Fleishman		12.90	11.32				
2-25	764.9	37256	056		J. MILLER		22.98	20.0				
2-28	768.1	37431	056		B. Schocer				11 9/16			
3/7	771.6	37565	056		C. HODGES							
3/10	773.6	37665	056		C. HODGES							
3/11	774.0	37670	056		G. Fleischmin					10.5	18.5	
3/11	774.1	37673	056	Los Angeles	G. Fleischman	Stinker Boise	15.8	13.63				
3/12	784.6	38254	056	Bishop	G. Fleischman	Chevron	22.26	16.87				
3/16	799.5	38808	056	Los Angeles	G. Fleischman	MTA card fuel	~~[illegible]~~	14.55		13 3/8	18.5	
3/16	800.3	38820	056		G. Fleischman	Mobil-LA	2.00	1.49				
3/19	814.9	39572	056	Winnemucca	G. Fleischman	Flying J, Winnemucca	28.13	22.02				
3/19/94	819.5	39832	056	Boise	G. Fleischman							
3/21/94	819.5	39832	056		G. Fleischman					13"	18 1/8	
3/23/94		39843	056		G. Fleischman		13.20	8.8				
3/24/94	824.8	40120	056	TWIN F. + RETURN	B. Schocer							
			056									
			056									
			056									
			056									

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. * Beginning of program.

12-15-93 – This station offers ~~to~~ the choice of No. 1 or No. 2 diesel to its customers all year.

1-5-94 – Bed cover installed – approximately 1-5-94

3/8/94 – ENGINE QUIT 35,380 MI, FUEL PROBLEMS, SHORT IN ELECTRICAL SYSTEM. MISTOOK FOR FILTER AND DID REPLACE. UNHOOKED RME CIRCUIT, TURNED OFF COOLING CIRC BOX AND WAS ABLE TO DRIVE. NOTICE SPORADIC VOLTAGE DROP, LIGHTS GREW DIM A FEW TIMES THEN QUIT.

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup Station	$	Gal	RME (In)	RME Fillup Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
4-4-94	825.2	40127 *	056	McCall-Sandpoint	G. Fleischman	Stinker-State St.	11.67	9.98				
4-4	831.9	40450*	056	Moscow	"	Univ of Idaho		8.30	13"	13"	18.5	
4-8-94	845.7	41102 *	056	Boise	"	Stinker-State St	9.83	16.96				
4/18-94	846.7	41121	056	BSU	G. Fleischman							
4/20	854.9	41576 *	056	Boise	J Miller	Texaco - I.F.	10.00	8.85				
	860.2	41877 *	056	Boise	G. Fleischman	Stinker-Orchard	19.54	16.71	11 5/8"			
4/25	866.7	42197 *	056	Bend	G. Fleischman	BP-Bend	14.00	10.78				
4/29/94	872.9	42532 *	056	Boise	G. Fleischman	Stinker-Orchard	12.67	10.84	8 11/16	8 11/16	18.5	
5/3/94	878.0	42824	056	Idaho Falls	S. Stoltz	Texaco	$8.00	6.95				
5/5/94	885.4	43223	056	Boise	G. Fleischman	Stinker-Orchard	16.65	13.89	15"			
		43241	056									*changed ~~oil and~~ fuel filter
5/6/94	891.6	43516*	056	Jerome	S. King	"						
5/11/94	893.7	43582	056	Horseshoe Bend	"	—	10.79	9.00	-			
5/13/94	903.[illegible]	43945 *	056	[illegible]	.							
5/17/94	908.2	44287*	056	Twin Falls	[illegible]	[illegible]	17.65	14.72				
5/20/94	914.7	44588*	056	Boise	G. Fleischman	[illegible]	13.06	11.2				
5/23/94	914.8	44590	056		G. Fleischman	Na Look Base	12.80	9.3	8"			
5/24/94	915.1	44592	056	Boise	G. Fleischman G. Galinato					7 3/4"	17 1/4"	
5-27-94	922.5	44955	056	TF-Boise	B. Schroeder							
6-3-94	937.5	45725	056	Rexburg-Rexburg	B. Schroeder	Stinker Boise	16.00	15.01				
6-8-94	947.7	46172	056	Burley-[illegible]	B. Schroeder	Boise-Stinker	28.00	23.35	12.5			
						"	17.00	14.19				

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. **Beginning of program.

*4-21-94 - The fuel filter plugged when Jared and Burke were driving it back from Twin Falls on 4/20. I changed it today 9.3.

6/7/94 - CHANGED FUEL FILTER @ 45,900 AND 941.0 HRS

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL						OIL Chevron Delco 400 15W-40 ONLY
						Diesel Fillup				RME Fillup		
						Station	$	Gal	RME (In)	Inches Before	Inches After	
6-9	953.6	46472	056	Moscow	G. Fleischman	U of I		6.5	8½	8.5	18.5	Changed*
6-10-94	963.4	46995	056	Boise	G. Fleischman	Stinker Orchard Boise	10.79	9.003	15 3/8			
6-16-94	973.1	47469	056	Boise	B. Scholer	Stinker Orchard Boise	20.61	17.188	13 1/8			
6/23	985.3	48023	056	BOISE	B SCHOLER	TEXACO-I.F.	24.00	20.7				
6/24	989.8	48311	056	BOISE	J. MILLER	STINKER-BOI	10.70	9.2	9.5			
	992.3	48431	056									
7-6		48530	056	Changed	filter							
7-7-94	1004	48784	056	Boise	G. Fleischman	Stinker-State	17.49	15.09	6 7/8			
8-15-94	1008.6	49099	056	MOSCOW	~~[illegible]~~	U OF I		10.38	4	4	18	chngd fuel filter
8-16-94	~~[illegible]~~ 1014.5	49318	056	Spokane	D. Reece	U of I		8.7	17 3/4			chngd oil
8-23	1021.0	49606	056	3 Rivers	C. Peterson	U of I		5.0	16"			
9-6-94	1028.5	49932	056	Moscow	G. Fleischman	Stinker-State	10.31	8.46				
9-7-94	1039.6	50516	056	Boise	G. Fleishman	Stinker-State	18.16	14.896	10 3/4"			
9-8-94	1041.0	50567	056	Nampa	G. Fleischman							
9/15/94	1041.8	50593	056	LOCAL	J. MILLER							
9/29/94	1042.6	50602	056		G. Fleischman					5 7/8"	16 3/4"	
10/5/94	1052.6	51194	056	~~Reno~~ Reno	G. Fleischman	Flying J Winnemucca	13.69	11.23				
10/6/94	1057.1	51455	056	Boise	G. Fleischman	Stinker Orchard	11.11	8.55	10 3/4"			
10/12/94	1068.8	51933	056	BOISE	J. MILLER	CHEV-REXBURG	19.50	15.0				
10/13/94	1073.9	52223	056	BOISE	J. MILLER	~~[illegible]~~-BOISE	10.80	7.8	7½"			
10-25-	1080.2	52550	056	Moscow				7.85	5 1/8	5 1/8	16"	chngd oil

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. **Beginning of program.

7-6 48530 - Replaced fuel filter due to power loss

10/11 51599 - " " " " " " " (1062.4 Hr)

	DATE	ENDING HOURS	ENDING MILEAGE (Indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)		DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup: Station	$	Gal	RME (ful)	RME Fillup: Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
	10-25	1080.9	52550	056		—	—	—	—	Full	15½			
	10-26-94	1087.7	52861	056		Boise	G. Fleishman	Stinker-Orchard	16.42	12.641				
	11/3/94	1097.6	53321	056		~~[illegible]~~ Rexburg	J. Watkins	Chevron	12.69	11.2				
	11/7/94	1105.2	53685	056		Boise	G. Fleischman	~~Stinker Front~~	16.38					
	11/[illegible]/94	1105.4	53688	056		Local	G. Fleischman	Stinker Front	~~[illegible]~~	12.60		11.5	16"	
	11/11/94	1118.4	54293	056		Moscow	G. Fleischman	Stinker, State	25.20	19.857				
	11/28/94	1126.4	54647	056		BURLEY	J. MILLER	" ORCHARD	19.50	15.0	11.27			
	12/1/94	1133.3	54997	056		BOISE	J. MILLER	" "	17.25	13.3	13"			
*	12/[illegible]/94	1135.5	55265	056		Twin Falls	G. Fleischman	" "	[illegible]	~~[illegible]~~	11.75			
	1/3/95	1141.7	55393	056		Payette	J. Beal							*changed Oil
	1/10/95	1142.6	55431	056		NAMPA	J. CROCKETT							
	1/12/95	1145.6	55537	056		Nampa	ww/J. Crockett							
	1/17/95	1146.1	55562	056		Local	G. Fleishman							
	1/19/95	1150.7	55749	056		GRANDVIEW	J. CROCKETT							
**	1/23/95	1152.2	55772	056			J. Crockett	Grand Del	20.90	18.188	16.5	9.5*	16.5	
	1/26/95	1161.6	56196	056		Poc/IF	J. CROCKETT	Chevron-A.F.	24.20	20.2 ***				
	1/27/95	1165.3	56414	056		Poc/IF	J. CROCKETT							
	2/6/95	1167.9	56520	056			G. Fleischman	Stinker-Orchard	14.29	12.121	12 7/8"			
	2/10/95	1175.0	56960	056		Portland	G. Fleishman	Texaco 26.60	~~[illegible]~~	19.8				
XX	2/11/95	1184.2	57426	056		Burns	~~Staff~~	Conoco	22.42	16.9				
	2/1[illegible]/95	1187.9	57618	056		Boise	G. Fleishman	Stinker-Chinden	9.03	7.632				

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. **Beginning of program.

* Fuel filter plugged in Twin Falls. Mileage about 55,100 miles

** ESTIMATED RME FILL UP (BEFORE)

XXX OVERFLOW - DIESEL PUMP DID NOT SHUT-OFF

XX Fuel filter plugged near Vale, OR 2/11/95 57498 miles

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL						OIL Chevron Delco 400 15W-40 ONLY
						Diesel Fillup				RME Fillup		
						Station	$	Gal	RME (In)	Inches Before	Inches After	
2/14/95	1195.2	57964	056	Moscow	G. Fleischman	Shell	19.40	14.705				
2/15/95	1202.0	58304	056	Boise	G. Fleischman	Stinker-Orchard	17.73	15.03		6.5	16 7/8"	* oil changed
2/23/95	1211.8	58810	056	REXBURG	J. MILLER	FOODE [illegible]	19.40	16.2				
2/27/95	1223.2	59409	056	BOISE	J. MILLER	STINKER-ORCH	24.00	20.3		13 1/2"		
2/27/95	1225.4	59497	056	Idaho City	G. Fleischman							
3/1/95	1233.9	59912	056	Rupert	S. King	STINKER-ORCH	20.40	17.3				
3/9/95	1245.9	60443	056	BOISE	J. MILLER	FLY J-LEWIS	19.71	17.6				
3/9/95	1251.9	60750	056	"	J. MILLER	STINKER-ORCH	17.59	15.30		8.5"		
3/24/95	1257.0	61017	056	Twin Falls-Boise	G. Fleischman	Stinker-Orchard	13.60	11.34		7 9/16"	16 3/4	* Oil changed
4/12/95	1268.8	61584	056	Sandpoint	G. Fleischman	Conoco-Cd'A	20.22	16.1				
4/13/95	1276.8	62008	056	BOISE	G. Fleischman	Stinker-Orchard	17.04	14.21				
4/20/95	1285.[illegible]	62417	056	BOISE	J. MILLER	CHEV-MOSES LK	20.80	16.5				
4/21/95	1291.3	62785	056	Boise	G. Fleischman	Stinker-Orchard	16.16	13.26		9 9/16	18 1/8"	
4/24/95	1293.6	62871	056	Idaho City	G. Fleischman							
* 5/2/95	1304.8	63580	056	Renewick-Boise	J. Crockett/GF	Nulook-Boise	31.86	23.10				[illegible]
5/9/95	1316.7	64027	056	Orofino	D. Greegor/GF	Stinker-Orchard	19.20	15.498				
5/10/95	1324.1	64442	056	Jerome	D. Tuthill	Texaco-Wendell	21.04	16.8				
5/10/95	1325.8	64603	056	Boise → Id Falls → Boise	D. Tuthill	End of Trip No Problems. Good ride						* Oil changed
5/11/95	1328.9	64708	056	Boise-Parma	D. Greegor							
5/21/95	1335.7	65141	056	Spokane	G. Fleischman	TEXACO	30.24	24.0				
5/30/95	1341.6	65655	056		G. Fleischman	Stinker-Orchard	23.16	18.69				

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. **Beginning of program.

* Changed fuel filter approximately 63400 miles, plugged near Baker City

327-7866

	HOURS	MILEAGE (Indicate mileage at diesel fillup with *)	TO PROJECT (UI only)		(Name not initials)	Diesel Fillup				RME Fillup		Chevron Delco 400 15W-40 ONLY
						Station	$	Gal	RME (In)	Inches Before	Inches After	
6/5/95	1357.8	66339	056	Moscow/Boise	G. Fleischman	Stinker-Orchard	29.73	23.61		3 11/16"	16 3/4"	
6/6/95	1363.4	66630	056	Twin Falls	W. Wehing	TEXACO-NAMPA	17.73	13.5				
6/7/95	1366.6	66780	056	Weiser	K. Reece							
6/8/95	1368.7	66879	056	Mtn Home	J. Crockett	Stinker-Orchard	4.99	3.966				
6/12/95	1376.5	67320	056	MacKay/Boise	D. Shaw							
6/14/95	1381.1	67534	056	McCall/Boise	D Shaw	Stinker-Orchard	.22	.178		5 13/16	10 3/4"	
6-19	1387.1	67836	056	Moscow	D. Reece	U of I		6.55		9	17 1/4	oil changed
6-26-95	1395.1	68202	056	Moscow/Boise	G. Fleischman	Stinker/Orchard	13.56	~~12~~ 11.359				
7-6-95	1397.3	68268	056	Emmett	G. Fleischman							
7-15-95	1407.3	68657	056	Wendell	S. King		~~21.03~~ 16.7	16.7				
7-20-95	1413.6	69022	056	Blackfoot	L. Campbell	Sinclair	15.67	12.4				
7-20-95	1418.1	69269	056	Boise	L Campbell							
7/26/95	1423.2	69515	056	Boise Twin Falls	W. Wehing	Stinker	21.50	17.1				
* 7/27/95	1430.5	69820	056	Boise	G. Fleischman	Stinker/Orchard	11.32	8.992				
7/28/95	1434.5	70035	056	Boise → Fairfield → Boi	DTuth	3/4 Tank Left						
8-2-95	1442.0	70380	056	Boise → Clayton → Boise	BRW/PATON	STINKER	12.59	8.076		[illegible]		
8-4-95	1442.0	70380	056	Stinker-Orchard	G. Fleischman	Stinker/Orchard	11.96	9.499 ✓		6 3/8"	16 5/8"	
8-8-95	1448.8	70757	056	Flying J McCammon	Norm Yurcek	Flying J	15.42	13.01				OK
8-8-95	1455.9	71146	056	Boise	Norm Yurek	Stinker	17.31	13.75				OK
8-8-95	1455.9	71148	056	Boise → Preston → Boise-Ret		N C	—	—				
8-14-95	1459.2	71220	056	HORSESHOE B.	J. MILLER							oil changed

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. * Beginning of program.

67534 - 2 new tires & 4 new shocks

* Fuel filter plugged - would only go 55 mph - changed fuel filter
69820 miles

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup: Station	$	Gal	RME (in)	RME Fillup: Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
8/16/95	1460.6	71307	056	McCall	G. Fleischman							
8/17/95	1461.5	71327	056	HP	J. Crockett							
8/24/95	1470.0	71835	056	Portland	G. Fleischman	Troutdale Krieger's	29.00	23.404				
** 8/28/95	1477.1	72265	056		G. Fleischman	Texaco - Virginia	19.50	15.013				
8/31/95	1485.2	72692*	056	Pocatello	L. Campbell	Phillips - Burley	18.90	15.505				
9/1/95	1488.7	72876	056	Boise	L. Campbell							
9/1/95	1489.1	72880	056	~~[illegible]~~	G. Fleischman	Gofer Garden City	7.52	5.926	$6\frac{15}{16}$"			
9/8/95	1492.5	73086	056	Tuttle	G. Fleischman				~~[illegible]~~			
9/11/95	1492.5	73086	056	2003 Diesel	G. Fleischman	Gofer Garden City	11.30	8.904	~~[illegible]~~	6.5"	$14\frac{7}{8}$"	
9/11/95	1497.7	73409	056	Rexburg	G. Fleischman	Phillips Rexburg	16.70	12.85				
9/14/95	1505.4	73808	056	Cody	G. Fleischman	Sinclair - Cody	13.83	11.16				
9/15/95	1515.5	74352	056	Return from Cody	G. Fleischman							
*** 9/25/95	1515.9	74359	056	~~Idaho Falls~~	G. Fleischman	Gofer Garden City	$6.10	4.693		4.25"	~~[illegible]~~	$16\frac{13}{16}$
** 9/26/95	1521.3	74654*	056	Idaho Falls	G. Galinato	Texaco - IDF	$12.54	10.00				
9/27/95	1526.8	74950*	056		G. Galinato	Maverik - Boise	14.13	10.47				
9/27/95	1527.5	74973	056		G. Galinato				$14\frac{3}{4}$"			
9/30/95	1541.7	75627	056	Twin Falls - Moscow	R. Rynk	Stinker - Fruitland	15.41	11.96	~~[illegible]~~			
10/3	1542.2	75642	056					11.7	$12\frac{1}{4}$		$17\frac{5}{8}$	
10/	1548.6	75887	056	Spokane - Moscow	D. Reece			10.0				
10/22	1553.1	76080	056		D. Reece	Busch		6.1	$16\frac{1}{2}$			
			056									

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. **Beginning of program.

** replaced left tail light lens
*** replaced RME Tank check valve

Note: Dome light does not work.

Daryl Reece

Date	HOURS	MILEAGE (Indicate mileage at diesel fillup with *)	TO PROJECT (UI only)		(Name not initials)	Diesel Fillup: Station	Diesel Fillup: $	Diesel Fillup: Gal	RME (in)	RME Fillup: Inches Before	RME Fillup: Inches After	Chevron Delco 400 15W-40 ONLY
10/27/95	1572.9	77060	056		G. Fleischman	Gofer Garden City	17.73	13.243				
11-3-95	1581.6	77451	056	375 miles Buhl + Return	B. Schelon							
11-3-95	1581.7	77452	056		G. Fleischman	Gofer - Garden City	20.50	15.376	11.25			
11-8-95	1588.2	77806 *	056		L. Campbell	Gofer - Garden City	18.12	13.53				
11-8-95	1589.2	77842	056	Rupert	L. Campbell							
11/11/95	1599.0	78305	056	Coeur d'Alene	G. Fleischman	Conoco City	22.06	17.0				
11/21/95	1607.2	78710	056	Boise	G. Fleischman	Gofer Garden City	18.31	13.47	6.75			
11/22/95		78899	056	Cascade & Return	D. Tuthill							
11/27/95	1611.9	79104	056		G. Fleischman	Gofer Garden City	8.76	6.444				* Oil change
11/29/95	1620.8	79468	056	Kenworth & return	G. Fleischman	Sinclair-Caldwell	30.27	23.121				
12/4/95	1626.4	79785	056	Twin Falls	W. Weihing							
12/5/95	1626.4	79785	056		G. Fleischman	Gofer Garden City	17.74	13.057		3 3/8	18"	
12/12/95	1632.5	80041*	056	Haselman	K. Neely	Gofer Garden City	11.50	8.46				
12/19/95	1634.6	80156	056	Payette	D. Tuthill	N/A (1/4 Tank used)						
1/3/96	1635.9	80188	056	Eagle	K. Neely							
1/5/96	1636.2	80190	056		G. Fleischman	Gofer Garden City	6.88	5.063				
1/5/96	1642.7	80558	056	Ellensburg	G. Fleischman	Texaco	20.51	15.714				
1/11/96	1653.2	81074	056	[illegible] Vintage	G. Fleischman	Texaco	22.20	16.7				
1/11/96	1659.2	81457*	056	Boise	G. Fleischman	Gofer Garden City	21.14	16.148				
1/19/96	1660.1	81467	056	Western States Cat	G. Fleischman							
1/26/96	1660.6	81490	056	Simplot [illegible]	G. Fleischman							

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. * Beginning of program.

11-4 installed new coolant pump

11/19 Fuel Filter changed and ~~[illegible]~~ tank heater switch kibelked

Daryl Reece

		HOURS	MILEAGE (Indicate mileage at diesel fillup with *)	TO PROJECT (UI only) 82404		(Name not initials)	Diesel Fillup Station	$	Gal	RME (In)	RME Fillup Inches Before	Inches After	Chevron Delco 400 15W-40 ONLY
	2-3	1671.0	81966	056		G. Galnata	Texaco Portland	29.50	2.24				
	2-5	1683.0	82607	056	Cambridge & Ret	D. Tuthill	BIK Canyon Sin	24.78	20.32				
	2-6	1683.0	82607	056		G. Fleischman					7.5"	17"	changed oil
**	2-7-96	1684.0	82617	056		G. Fleischman	Gofer Garden City	8.76	6.689				
	2-8-96	1688.5	82824	056	Donnelly & Ret	D. Tuthill	Stinker Eagle	6.68	5.2				
+	2-9-96	1694.0	83124	056	TWIN FALL	HELEN HARRINGTON THORNTON	Go-fer Boise	16.15	11.57				
	2/21/96	~~1702~~.8	83640	056	Aston	W. Weithing	Sinclair	24.01	19.2				
	2/24/96	1712.4	84116	056	Boise	W. Weithing	Cfm	25.00	19.6				
	2/28/96	1719.8	84415	056	Twin Falls	K. Neely	Go-fer Boise	14.10	11.1				
	2/29/96	1727.3	84683	056	Twin Falls	W. Weithing	Go-fer Boise	13.50	10.6				
	3/4/96	1729.0	84912	056	Wendell	S. King	Go-Fer Chicken	12.70	10.0				
1	3/8/96	1729	84913	056		G. Fleischman					8.5	18"	
	3/8/96	1730.5	84974	056	Caldwell	G. Fleischman							
	3/11/96	1735.7	85311	056	Burley	G. Fleischman	Gofer Chicken	19.68	15.507				
	3/18/96	1738.1	85429	056	Payette	D. Tuthill	N/A						
	3/19/96	1738.4	85438	056	Western States	G. Fleischman							changed oil
	3/25/96	1743.0	85685	056	Jerome	G. Fleischman	Gofer Chicken	17.11	15.059				
	3/28/96	1749.7	86042	056	Twin Falls	G. Fleischman	Sinclair's	16.37	13.2				
	3/31/96	1755.0	86330	056		G. Fleischman	Gofer Chicken	14.88	11.728				
	4/3/96	1756.6	86364	056	Eagle	K. Neely							
2	4/4/96	1762.7	86663	056	Jerome	W. Weithing	Gofer Chicken	17.18	13.122				

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. *Beginning of program.

** 3 vertical scratches appeared in right passenger window

+ PASSENGER SIDE REAR VIEW MIRROR MISSING.

1 just noticed dent in right-rear wheel hubcap

2. Changed from studded snow tires to regular

Post-it® Fax Note 7671	Date 4/8	# of pages ▶ 1
To Waryl Reece	From Gerald Fleischman	
Co./Dept.	Co. IDWR	
Phone #	Phone # 208-327-7959	
Fax # 208-885-8923	Fax # 208-327-7866	

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup: Station	$	Gal	RME (in)	RME Fillup: Inches Before	Inches After	OIL Chevr Delco 15W- ONLY
4/8/96	1765.5	86195	056	Payette	D. Tuthill	(only ¼ tank used - not refilled)						
4/9/-	1769.7	87,037	056	Jerome	Ralph Molli	(Tank @	3070	not	refilled)			
4/10/96	1769.8	87038	056		C. Fleischman	Gofer Garden City	20.95	15.63				
4/11/96	1774.5	87307	056	Idaho Falls	C. Fleischman	Beard's IF.	15.66	11.[illegible]		11.45		
4/11/96	1779.6	87609	056		C Fleischman	Gofer-Garden City	19.83	13.874	7 3/16	6 5/8"	13.5"	
4/19/96			056		S. Hennessey	Sinclair, Riggins	28.62	18.48				
4/20/96	1789.9	88033	056	Riggins	S. Hennessey	1/4 tank used - not	refilled					
4/22/96	•	88043*	056	Eagle	Spackman	Eagle Chevron	6.58	10.00				
4/24/96	1800.5	88546	056	Salmon	Spackman	Gofer Garden City	22.25	15.25				OK
5/3/96	1801.1	88555	056		G. Fleischman							
5/9/96	1804.8	88727	056	Cascade	D. Tuthill	Eagle Stinker	8.45	5.6				
5/10/96	1810.1	88982	056	Mtn Home/Load	G. Fleischman							
5/11	1810.4	89634	056	Arco	Ralph M.	Texaco - Diesel	22.36	14.2				
5/17/96	1820.4	89634	056		G. Fleischman					4 5/8"	17 6/16	
5/18/96		89635*	056		Gary Spackman	Gofer-Garden City	31.50	20.6				
5/19/96	1827.5	90063	056	Malta	Gary Spackman	Gofer-Garden City	26.3[illegible]	17.2				OK
5/20/96	1834.4	90480	056	Yellowstone	C. Fleischman	Phillips 66 Idaho Falls	26.16	15.85				
5/24/96	1847.1	91027	056	end trip to Yellowstone	G. Fleischman							
5/24/96	1849.4	91141	056	Ontario	B. Minter	—	—	—				
5/30/96	1851.1	91291	056	Weiser	K Baker	TEXACO-BOISE	35.00	21.88		.		OK
6/13/96	1854.1	91348	056	Nampa/Caldwell	B. Minter							

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles and the reason, etc. *Beginning of program.

1. Cruise control - appears you need to push decelleration then accelleration to set speed after pushing on.
• A set of ear plugs in ash tray would be nice to lessen disel noise
Truck rides good on highway
2. fuel Leak - Daryl Reece came down to repair it

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL: Diesel Fillup: Station	$	Gal	RME (In)	RME Fillup: Inches Before	Inches After	OIL Chevron Delco 400 15W-40 ONLY
6/6/96	1855.8	91412	056	Emmett	G. Fleischman							
6/10/96	1856.2	91415	056		G. Fleischman	Gofer Garden City	13.99	9.151				
6/10/96	1858.5	91535	056	Payette	D. Tuthill	3/4 Full still						
6/12/96	1864.5	91856	056	Gooding	D. Tuthill	Gofer Garden City	22.66	15.1				
6/13/96	1865.1	91871	056	McCall [illegible]	J. Bod[illegible]	[illegible]	[illegible]	[illegible]	23.3			
6/14/96	1865.6	91886	056		G. Fleischman							Oil Changed
		9[illegible]	056	Ketchum	C. Culincto							
7/3/96	1883.9	92856	056	Aberdeen	[illegible]	Gofer Garden City	21.46	15.731		4.25	12.5	
7/10/96	1894.2	93471	056	Twin Falls/[illegible]	D. Tuthill	Mtn Home Chevron	33.78	23.1				
7/15/96	1896.8	93593	056	Payette	D. Tuthill	Black Canyon	6.55	5.1				
7/18/96	1909.5	94186*	056	Richfield	G. Sparkman	Bliss Texaco	27.50	21.9				OK
7/19/96	1911.1	94277	056	"	G. Sparkman							
7/29/96	1911.2	94275	056		G. Fleischman					11 5/8"	18 3/16	
7/30-31/96	1935.3	94920	056	Idaho Falls	R. McCarthy	Sinclair	30.54	~~20~~.57				
7/31/96		94943	056	M.H. → Boise	" "							
8/8/96	1937.3	95529	056	Twin Falls Area	L. Campbell	Sinclair-Twin	27.57	21.2				
8/9/96	1942.8	95751	056	Twin → Boise	L. Campbell	Gofer Garden City	11.00	8.1				
8/12/96	1944	95858	056	Caldwell	G. Fleischman							
8/13/96	1946	95902	056	Murphy	D. Tuthill							
8/14/96	1946.4	95974	056	"	G. Fleischman							Oil Changed
8/19/96	1946.8	95915	056	Pocatello	L. Campbell	Getty Garden City	7.34	5.36				

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. **Beginning of program.

DATE	ENDING HOURS	ENDING MILEAGE (indicate mileage at diesel fillup with *)	CHARGE TO PROJECT (UI only)	DESTINATION	DRIVER (Name not initials)	FUEL						OIL Chevron Delco 400 15W-40 ONLY
						Diesel Fillup				RME Fillup		
						Station	$	Gal	RME (In)	Inches Before	Inches After	
5/23/96	1959.9	96496	056	Boise	L. Campbell	Cities C.C.	28.18	20.58		7 3/16	17"	D.
8/30/96	1968.4	96965	056	Twin Falls	L. Campbell	66 Bailey	26.81	19.9				
9/2/96	1974.2	97311	056	Boise	L. Campbell	Cities C.C	17.61	14.0				
9/10/96	1983.1	97872*	056	Idaho Falls	D. Shafer	Jackson's Country	32-	22.24				
9/11/96	1989.4	98246	056	~~Island Park~~	D. Tuthill	Island Park	~~13~~ $20.24	13.5				
9/12/96	1998.7	98792	056	Bozeman Mt.	D. Tuthill	Jacksons Cities	27.25	19.1				
9/16/96	1999.3	98803	056	Local	G. Fleishman							
9/18/96	2003.[illegible]	99102	056	Twin Falls	G. Fleishman	Beckers IF	18.16	12.8				*Oil changed
9/20/96	2008.5	99355	056		G. Fleishman	Cities-Cities	16.45	10.771		5 3/8	10"	
9/24/96	2020.0	99956	056	~~Pomeroy~~ OR	Nabil M	Pomeroy, OR	29.45	19.731				
9/25/96	2023.2	100179	056	Boise	Nabil M							
[illegible]	2024.2	100[illegible]	056	Local	Fleishman							
10/2/96	2028.3	100453	056	Twin Falls	D. Tuthill	Jacksons Cities	29.76	19.3				**
			056									
			056									
			056									
			056									
			056									
			056									
			056									
			056									

COMMENTS: (Performance, noises, unusual behavior, starting trouble, operating trouble, fuel problems, mechanical problems. If RME is not used, the miles driven and the reason, etc. **Beginning of program.

** – front brake rotors replaced
pack front wheel bearings

Appendix D

Dynamometer Test Reports

Dodge pickup dynomometer run #1 with 1475 miles

VehPwr	R1 Spd	R1 Pwr	VBSFC	V Cpwr	V CSpd	Fuel M	Fuel V	Econ	VBSFC	CBSFC	TstTime
100% ME											
91	37.1	91	0.49	94	38.2	50.3	6.80	5.45	0.552	0.536	78
104	42.1	104	0.48	107	43.5	51.9	7.00	6	0.5	0.484	120
117	47	117	0.49	120	48.4	56.4	7.60	6.16	0.484	0.47	175
126	52.2	126	0.49	130	53.7	59.3	8.00	6.51	0.47	0.457	223
132	57	132	0.49	136	58.6	68.9	9.30	6.11	0.52	0.506	271
129	62.2	129	0.49	132	63.7	72.7	9.80	6.32	0.566	0.553	323
73	68.2	73	0.5	73	68.9	50.3	6.80	10.02	0.693	0.687	366
2nd run on Blend											
95	37	95	0.48	98	38.2	47.4	6.50	5.65	0.501	0.485	83
108	41.9	108	0.48	111	43.3	46.8	6.50	6.49	0.435	0.421	128
121	47	121	0.48	125	48.5	51.6	7.10	6.61	0.427	0.414	192
131	51.8	131	0.48	135	53.4	57.4	7.90	6.54	0.438	0.425	247
137	57	137	0.49	142	58.7	66	9.10	6.26	0.48	0.466	294
135	62.2	135	0.49	138	63.8	62.2	8.60	7.25	0.461	0.449	341
80	68	80	0.49	81	68.3	47.1	6.50	10.46	0.597	0.58	383
run1 on blend											
87	34.5	87	0.48	90	35.7	38.5	5.30	6.51	0.441	0.426	82
99	39.5	99	0.48	103	40.9	47.1	6.50	6.07	0.474	0.459	125
113	44.8	113	0.48	117	46.3	48.4	6.70	6.7	0.428	0.414	179
125	49.3	125	0.48	129	50.9	55.8	7.70	6.41	0.445	0.432	227
134	54.4	134	0.48	135	56.2	58.6	8.10	6.73	0.437	0.423	278
136	59.6	136	0.49	140	61.2	67.3	9.30	6.42	0.494	0.481	335
120	64.9	120	0.49	123	66.4	62.2	8.60	7.57	0.517	0.506	372
100% diesel											
106	39.5	106	0.48	109	40.7	43.9	6.10	6.43	0.416	0.403	87
116	44.3	116	0.49	119	45.7	48.1	6.70	6.59	0.415	0.403	132
130	49.3	130	0.48	134	51	54.5	7.60	6.49	0.42	0.408	170
138	54.6	138	0.49	142	56	61.2	8.60	6.37	0.443	0.431	246
140	59.6	140	0.49	144	61.2	64.4	9.00	6.61	0.461	0.449	293
124	64.9	124	0.49	126	66.3	65.1	8.80	7.35	0.509	0.499	336

RPM	Opacity	Torque	Fuel T Tank F	Oil P	MAP	Fuel P	Baro P	Blowby	Exh T F	Inlet Air Temp F	Coolant Temp F	Fuel Temp (F)
100% ME												
1497	1.7	1377	79.5	39.9	16.09	5.1	27.54	0.37	685	111	184	100
1708	0.2	1380	79.2	46.1	19.47	0.6	27.54	0.41	703	115	184	100
1898	0.1	1389	78.9	48	23.14	4.6	27.54	0.48	720	118	185	99
2106	0.1	1353	79.2	48.9	25.83	3.9	27.54	0.47	728	125	186	98
2299	0.2	1302	79.2	49.4	28.91	2.6	27.54	0.62	738	127	187	98
2498	0.6	1158	79.5	50.2	29.8	2.5	27.54	0.61	745	129	191	98
2702	0.5	596	79.2	51.7	19.37	2.8	27.54	0.54	702	130	190	99
2nd run on Blend												
1496	4	1436	82.1	44.3	17.28	4.1	27.56	0.44	572	104	178	102
1696	0.9	1438	82.4	47.9	20.76	4	27.56	0.43	639	109	178	101
1902	0.5	1438	82.4	49	24.54	3.9	27.56	0.49	699	118	179	100
2093	0.6	1416	82.7	49.7	27.92	3.7	27.56	0.53	728	121	182	100
2302	0.7	1350	82.7	50	30.9	3.6	27.56	0.63	750	126	186	100
2500	0.6	1216	82.9	50.7	32.19	3.4	27.56	0.82	765	127	190	100
2695	0.4	662	82.9	52.1	21.45	3.6	27.56	0.7	724	128	190	101
run1 on blend												
1399	5.3	1414	81.2	36.2	15.39	4.2	27.56	0.38	685	109	182	102
1598	1.6	1409	81.2	42.9	18.97	4.1	27.56	0.45	710	110	183	102
1811	0.6	1414	81.5	47.1	22.85	3.9	27.56	0.45	732	117	184	101
1993	0.6	1421	81.5	48.2	26.23	3.7	27.56	0.48	747	123	186	100
2201	0.7	1380	81.5	49.1	29.41	3.6	27.56	0.53	760	127	189	100
2398	0.7	1230	81.8	49.5	31.69	3.5	27.56	0.62	773	129	193	100
2598	0.5	1038	81.8	50.6	29.41	3.4	27.56	0.76	765	129	194	100
100% diesel												
1599	2.4	1499	75.1	45.8	19.47	3.7	27.59	0.37	539	95	0	93
1794	1	1463	75.1	50.6	23.14	3.6	27.59	0.42	618	101	0	92
2003	0.8	1468	75.1	51.3	27.22	3.4	27.59	0.46	683	112	0	92
2201	0.7	1419	75.1	51.5	30.3	3.4	27.59	0.57	720	116	0	93
2403	0.9	1314	75.1	52.1	32.39	3.2	27.59	0.63	744	120	0	93
2602	0.8	1070	75.4	52.8	30.3	3.1	27.59	0.6	746	123	0	94

Second Dyno Test for Dodge Pickup with 10,500 miles on 12-18-92
D2 was run first, Blend second and 100%RME last

100% Diesel

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
114	39.7	114	117	40.5	46.8	6.50	6.12	0.409	0.401	1599	1.7
129	43.4	129	132		53.8	7.50	5.81	0.417	0.409	1748	1.3
140	47.2	140	143	48.1	54.5	7.60	6.24	0.39	0.382	1898	1
147	50.9	147	150	51.9	58	8.00	6.33	0.394	0.387	2048	1
150	54.7	150	153	55.7	62.2	8.60	6.35	0.414	0.407	2200	0.9
154	58.6	154	156	59.6	65.7	9.10	6.44	0.428	0.42	2354	1.1
148	62.3	148	150	63.2	67.6	9.40	6.65	0.457	0.45	2496	1.1
114	66.4	114	116	67.1	58	8.00	8.27	0.507	0.502	2648	0.7

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Tem deg F
1599	1614	46.1	52.7	20.96	1.9	27.76	0.46	454	36	150	63
1748	1665	46.1	53.2	24.44	1.5	27.76	0.43	547	36	161	60
1898	1661	46.7	53.4	28.01	1.5	27.76	0.51	604	36	168	58
2048	1619	47.3	53.6	30.6	1.4	27.76	0.52	644	48	173	58
2200	1536	47.6	54	32.39	1.6	27.76	0.49	678	55	168	58
2354	1468	47.9	54.5	34.38	1.5	27.76	0.46	696	60	168	59
2496	1331	48.1	54.9	34.77	1.5	27.76	0.56	709	61	168	60
2648	965	48.7	55.7	28.71	1.6	27.76	0.41	674	63	167	62

80-20 Blend

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
114	39.7	114	117	40.6	46.1	6.40	6.23	0.404	0.395	1599	0.9
125	43.4	125	128	44.4	50	6.90	6.29	0.399	0.39	1750	0.5
132	47.1	132	135	48.1	53.8	7.40	6.34	0.406	0.398	1895	0.5
143	50.8	143	146	52	58.3	8.10	6.31	0.409	0.4	2048	0.5
146	54.9	146	149	56	61.8	8.50	6.43	0.423	0.414	2207	0.5
146	58.5	146	149	59.6	65.7	9.10	6.45	0.449	0.441	2349	0.7
142	62.4	142	145	63.5	67.9	9.40	6.66	0.478	0.47	2503	0.7
110	66.4	110	111	67.2	57.7	8.00	8.35	0.526	0.52	2646	0.5

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Tem deg F
1599	1612	60	50.2	20.96	1.2	27.78	0.35	577	44	165	68
1750	1617	60	51.2	24.34	1.2	27.78	0.37	622	48	170	68
1895	1575	60	51.8	27.22	1.2	27.78	0.45	652	55	172	68
2048	1573	60	52.6	29.51	1.2	27.78	0.43	673	51	169	68
2207	1492	60	53.1	31	1.6	27.78	0.48	690	71	169	69
2349	1399	60	53.4	32.89	1.5	27.78	0.6	702	71	170	69
2503	1275	60.3	54.3	33.78	1.4	27.78	0.54	707	55	168	70
2646	926	60.9	55.2	27.62	1.5	27.78	0.5	667	59	168	70

100%RME

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
106	39.8	106	108	40.3	45.8	6.30	6.37	0.431	0.425	1599	0.3
119	43.5	119	121	44.1	51.3	7.00	6.22	0.431	0.425	1750	0.2
129	47.4	129	131	48	56.7	7.70	6.12	0.439	0.434	1903	0.2
	51	136	138	51.7	59.9	8.20	6.24	0.44	0.435	2050	0.2
139	54.8	139	141	55.5	63.8	8.70	6.30	0.458	0.452	2201	0.3
141	58.7	141	142	59.3	68.3	9.30	6.30	0.485	0.48	2351	0.4
133	62.6	133	134	63.1	68.6	9.40	6.69	0.515	0.511	2503	0.3
103	66.5	103	103	66.7	57.7	7.90	8.45	0.562	0.561	2644	0.2

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Tem deg F
1599	1497	82.1	48.8	19.37	1.4	27.76	0.37	660	57	165	83
1750	1534	81.8	50.3	22.35	1.2	27.76	0.36	665	49	170	82
1903	1526	81.8	51.1	24.93	1.2	27.76	0.4	669	60	173	82
2050	1494	81.8	52	27.12	1.1	27.76	0.39	673	58	171	82
2201	1424	81.8	52.6	28.81	1.1	27.76	0.48	680	75	169	82
2351	1343	81.8	53	30.8	1.1	27.76	0.49	687	68	170	82
2503	1192	81.8	53.8	31	1.1	27.76	0.44	691	75	170	82
2644	864	81.5	54.9	25.63	1.3	27.76	0.45	640	63	170	83

Third Dyno Test for Dodge Pickup with 20,033 miles on 6-1-93

100% Diesel

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
108	39.6	108	110	40.4	44.5	6.20	6.40	0.413	0.405	1599	2.8
119	43.4	119	121	44.2	48.7	6.80	6.41	0.411	0.404	1750	1.5
128	47.1	128	131	47.9	51.9	7.20	6.54	0.404	0.397	1900	1.2
136	50.8	136	138	51.7	56.7	7.90	6.44	0.418	0.411	2047	1.1
141	54.7	141	143	55.6	61.5	8.50	6.40	0.437	0.43	2202	1.2
143	58.4	143	145	59.3	64.1	8.90	6.57	0.448	0.442	2350	1.5
140	62.3	140	142	63.1	66	9.20	6.80	0.472	0.466	2500	1.5
105	66.6	105	106	66.9	54.5	7.60	8.80	0.517	0.515	2651	0.8

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Tem deg F
1599	1526	72.5	48	20.36	2.6	27.67	0.45	677	84	178	88
1750	1531	72.5	49.4	23.34	2.5	27.67	0.39	703	89	178	88
1900	1526	72.8	50.2	25.73	2.4	27.67	0.49	719	92	179	88
2047	1497	72.5	51	27.92	2.2	27.67	0.38	729	98	179	88
2202	1443	72.8	51.8	30	2.1	27.67	0.53	738	87	181	88
2350	1370	72.8	52	31.59	2	30.15	0.65	749	88	181	88
2500	1258	72.8	52.7	32.19	1.9	27.67	0.77	755	94	181	88
2651	886	72.8	53.9	25.33	2	27.99	0.69	706	95	180	90

80-20 Blend

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
110	39.2	110	113	40.6	46.1	6.40	6.16	0.421	0.407	1599	3.2
120	42.7	120	124	44.4	49.7	6.80	6.25	0.415	0.399	1751	2.6
130	46.5	130	135	48.2	55.1	7.60	6.12	0.424	0.409	1898	1.9
135	50.5	135	139	52	59	8.10	6.21	0.437	0.424	2049	1.7
141	54.4	141	144	55.8	62.2	8.60	6.35	0.442	0.431	2201	2.6
142	58.1	142	145	59.6	66.3	9.10	6.37	0.468	0.457	2347	2.2
138	62.1	138	141	63.5	68.3	9.40	6.61	0.495	0.485	2502	2.1
103	66.4	103	105	67.3	56.1	7.70	8.60	0.543	0.536	2651	0.9

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Tem deg F
1599	1568	62.4	53.3	20.66	1.9	27.69	0.44	538	66	162	78
1751	1570	62.4	53.2	23.84	1.8	27.69	0.47	610	68	162	77
1898	1568	62.4	52.9	26.82	1.6	27.69	0.52	668	71	174	77
2049	1499	62.4	52.9	28.41	1.5	27.69	0.59	700	80	173	77
2201	1448	62.4	53.1	30.3	1.5	27.69	0.6	720	84	178	77
2347	1365	62.4	53	31.69	1.3	27.69	0.55	737	89	179	78
2502	1243	62.4	53.3	32.09	1.3	27.69	0.56	749	86	181	79
2651	872	62.6	54.4	25.43	1.5	27.69	0.4	697	92	177	81

100%RME

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
104	39.5	104	107	40.6	47.1	6.40	6.16	0.454	0.442	1599	1.3
114	43.2	114	117	44.3	51.3	7.00	6.19	0.45	0.438	1748	0.7
124	47.1	124	127	48.3	56.1	7.60	6.18	0.454	0.443	1905	0.6
131	50.7	131	134	51.9	60.6	8.20	6.16	0.462	0.451	2046	0.7
136	54.6	136	139	55.8	64.4	8.80	6.23	0.474	0.464	2200	0.6
137	58.5	137	140	59.6	67.6	9.20	6.36	0.494	0.485	2350	0.8
132	62.2	132	134	63.3	69.5	9.50	6.58	0.526	0.518	2495	0.9
99	66.5	99	100	67.2	57.7	7.80	8.48	0.583	0.577	2651	0.5

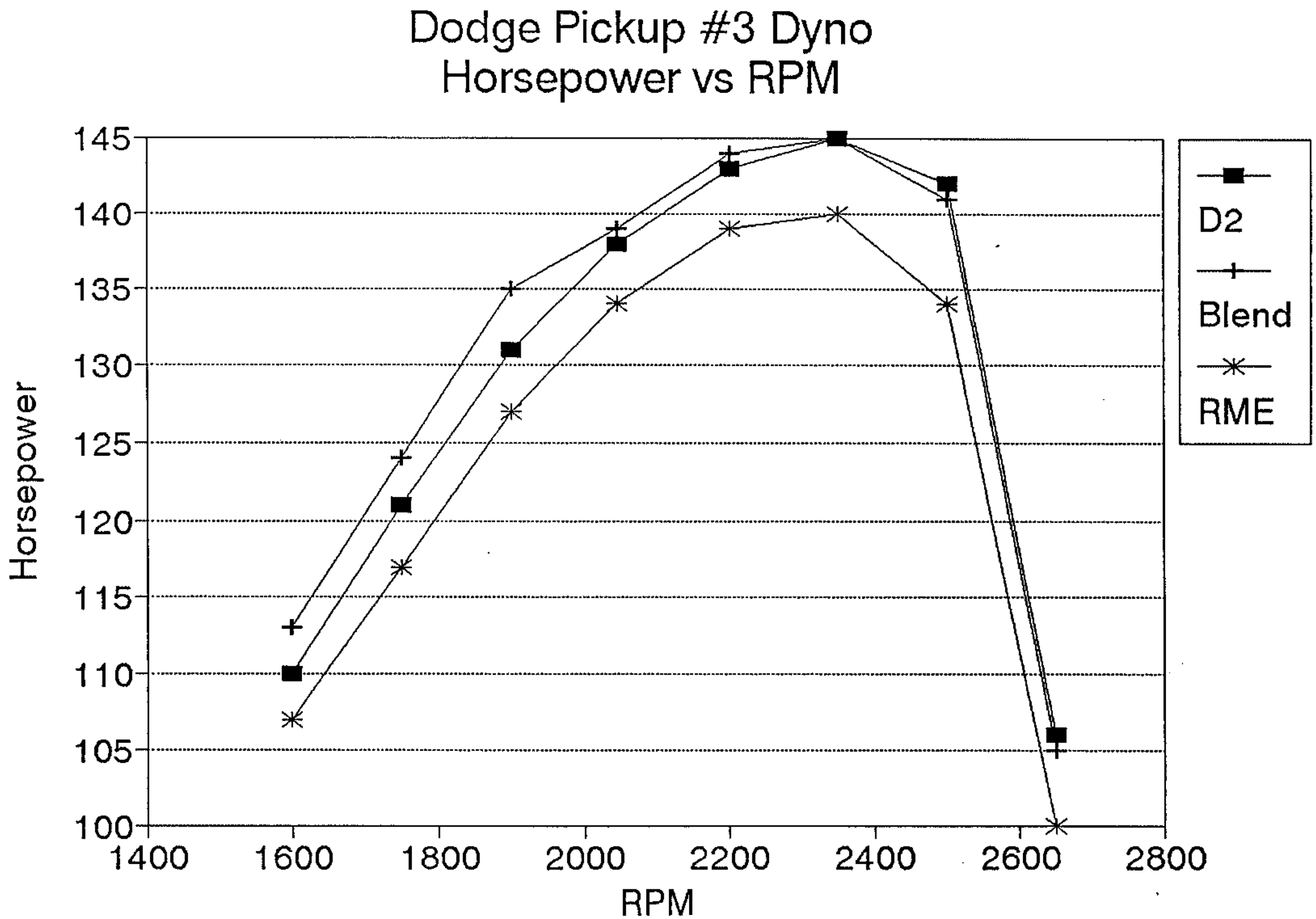
RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Tem deg F
1599	1473.0	68.7	47.8	18.37	2.2	27.69	0.34	654	86	175	84
1748	1477.0	68.7	49.3	21.16	2.2	27.69	0.5	678	88	175	84
1905	1468.0	68.7	50.1	23.94	2.1	27.69	0.42	695	86	181	84
2046	1448.0	68.7	50.9	25.83	2	27.69	0.4	704	89	178	84
2200	1394	68.7	51.6	27.72	1.8	27.69	0.41	716	94	179	84
2350	1311	68.7	51.9	29.11	1.2	27.69	0.55	724	92	181	84
2495	1189	68.7	52.6	29.41	0.9	27.69	0.87	729	98	181	84
2651	833	68.7	54.2	23.44	1	27.69	0.48	676	92	177	86

Snap Idle Test

Diesel	Blend	RME
10.3	6.4	6.4
12.1	8.6	6.4
13.9	9.1	6.5
12.1	8.0	6.4

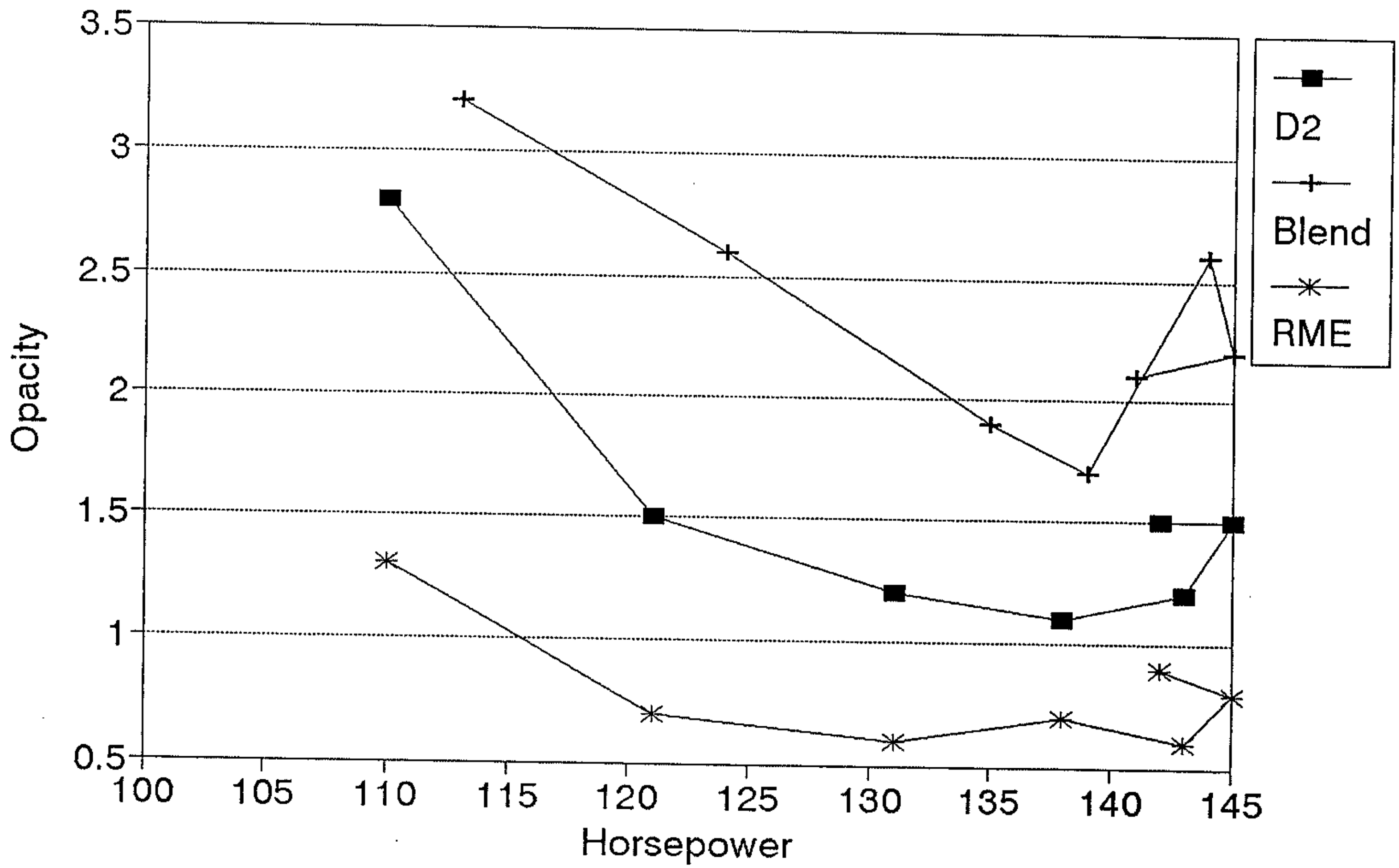
Dodge Dyno #3
Comparison of Biodiesel to that of 100% Diesel
Percent Reduction in Exh Temp, Opacity and Horsepower.

RPM	Exh Temp	Opacity	Horsepower
		20%RME, 80%D2	
1599	-20.5	-14.3	-2.7
1750	-13.2	-73.3	-2.5
1900	-7.1	-58.3	-3.1
2047	-4.0	-54.5	-0.7
2202	-2.4	-116.7	-0.7
2350	-1.6	-46.7	0.0
2500	-0.8	-40.0	0.7
2651	-1.3	-12.5	0.9
		100%RME	
1599	-3.4	-53.6	-2.7
1750	-3.6	-53.3	-3.3
1900	-3.3	-50.0	-3.1
2047	-3.4	-36.4	-2.9
2202	-3.0	-50.0	-2.8
2350	-3.3	-46.7	-3.4
2500	-3.4	-40.0	-5.6
2651	-4.2	-37.5	-5.7



Dodge Pickup #3 Dyno
Horsepower vs RPM
Horsepower
145
140
135
130
125
120
115
110
105
100
1400
1600
1800
2000
2200
2400
2600
2800
RPM
D2
Blend
RME

Dodge Pickup #3 Dyno
Opacity vs Horsepower



Fourth Dyno Test for Dodge Pickup with 32,628 miles on 12-22-93

100% Diesel

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
116	39.4	116	119	40.2	45.5	6.50	6.09	0.392	0.384	1585	3.2
128	43.5	128	131	44.4	49	7.00	6.24	0.383	0.376	1747	1.8
138	47.2	138	141	48.2	53.2	7.60	6.24	0.386	0.378	1898	1.6
141	51	141	144	52	56.7	8.10	6.32	0.402	0.395	2048	1.5
146	54.9	146	149	55.9	60.9	8.70	6.34	0.416	0.408	2202	1.5
147	58.7	147	150	59.7	62.8	8.90	6.57	0.427	0.42	2350	1.7
142	62.6	142	144	63.4	65.4	9.30	6.73	0.462	0.455	2499	1.7
109	67	109	110	67.6	53.2	7.60	8.86	0.487	0.482	2664	1.3

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Temp deg F
1585	1651	57.4	50.1	18.87	1.1	28.27	0	491	39	155	40
1747	1648	56.8	51.3	22.35	1.1	28.27	0	573	40	158	39
1898	1636	56.6	51.8	25.83	0.9	28.27	0	619	39	162	39
2048	1548	56.6	52.5	28.41	1.3	28.28	0	651	42	165	39
2202	1494	57.4	53.1	30.4	1	28.28	0	669	46	167	40
2350	1404	57.7	53.4	31.59	0.7	28.28	0	683	54	168	41
2499	1267	57.7	54	31.99	0.8	28.28	0	694	66	169	42
2664	913	57.7	55.7	25.13	0.9	28.28	0	653	54	167	43

80-20 Blend

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
116	39.4	116	118	40.3	48.1	6.80	5.83	0.416	0.407	1591	4.1
128	43.4	128	130	44.3	51.3	7.20	6.01	0.402	0.394	1749	3.2
140	47.1	140	143	48.1	56.1	7.90	5.97	0.401	0.393	1898	3.3
147	50.9	147	150	51.9	60.2	8.50	6.00	0.411	0.403	2048	3.4
151	54.1	151	153	55	63.1	8.90	6.08	0.419	0.412	2171	2.7
150	58.6	150	153	59.6	65.7	9.30	6.34	0.437	0.43	2350	2.3
143	62.6	143	145	63.4	67.6	9.50	6.58	0.473	0.467	2500	2.3
109	67	109	110	67.5	55.4	7.80	8.58	0.506	0.502	2664	1.5

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Temp deg F
1591	1641	49.6	57.3	20.66	1.7	28.21	0	473	36	139	44
1749	1646	49.6	57.5	24.24	1.7	28.21	0		37	144	43
1898	1663	49.6	56.9	27.62	1.6	28.23	0	604	39	150	43
2048	1614	49.9	56.6	30	1.6	28.23	0		42	155	42
2171	1560	49.9	56.5	31.69	1.9	28.21	0	675	41	161	42
2350	1436	50.2	56.2	33.28	1.9	28.23	0	699	48	165	42
2500	1280	50.5	56.1	33.28	1.8	28.23	0	711	62	168	43
2664	916	50.8	57.2	26.32	2.1	28.23	0		50	167	43

Snap Idle	Diesel	Blend	EME
	10.3	5.4	5.9
	[illegible]	5.1	5.2
	[illegible] 5	5.0	5.5
	10.1	5.3	~~5.5~~ 5.5

	Compr	VOP
1	490	3450
2	500	3600
3	490	3600
4	500	3600
5	450	3300
6	510	3300

100%RME

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
115	39.6	115	117	40.4	48.1	6.60	6.03	0.417	0.41	1591	1.9
125	43.5	125	128	44.4	51	7.00	6.24	0.406	0.398	1749	1.3
136	47.3	136	138	48.2	57.4	7.80	6.03	0.423	0.415	1899	1.1
142	51.1	142	145	52.1	62.8	8.60	5.95	0.441	0.432	2052	1.1
146	54.9	146	148	55.8	65.4	8.90	6.14	0.448	0.441	2200	1.1
142	58.6	142	144	59.5	68.3	9.30	6.28	0.48	0.473	2347	1.2
137	62.7	137	139	63.5	68.9	9.40	6.66	0.503	0.497	2505	1.2
102	66.8	102	103	67.3	58	7.90	8.43	0.569	0.565	2654	1

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Temp deg F
1591	1629.0	58.6	51.5	18.37	1.5	28.23	0	457	37	154	41
1749	1617.0	58.6	52.3	21.65	1.4	28.23	0	547	39	155	41
1899	1609.0	58.6	52.6	24.73	1.4	28.25	0	604	44	160	40
2052	1563.0	58.9	53.0	27.32	1.6	28.23	0	639	43	165	41
2200	1490	58.9	53.6	29.11	1.5	28.23	0	655	47	167	42
2347	1358	59.2	53.8	29.61	1.5	28.23	0	672	68	168	42
2505	1223	58.9	54.3	30.2	1.4	28.23	0	675	60	169	43
2654	855	59.2	55.8	23.64	1.7	28.25	0	649	67	168	44

Fifth Dyno Test for Dodge Pickup with 49,200 miles on Aug 16, 94

100% DIESEL

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
100	39.9	100			42.3	6.00	6.65	0.423		1597	3.4
109	43.7	109			45.8	6.50	6.71	0.42		1748	1.8
118	47.4	118			51	7.20	6.55	0.433		1902	1.2
125	51.2	125			54.5	7.70	6.62	0.435		2048	1.2
132	55.1	132			59.6	8.50	6.51	0.452		2206	1.1
134	58.9	134			63.8	9.10	6.50	0.475		2345	1.2
130	62.7	130			64.1	9.10	6.89	0.493		2500	1.8
88	67.2	88			49	7.00	9.66	0.558		2664	0.9

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Temp deg F
1597	1402	76.6	50	18.67	5.1	27.72	0.45	593	93	179	78
1748	1399	76.3	51	21.25	5.1	27.72	0.51	659	91	180	79
1902	1389	76.3	52.1	23.84	5	27.72	0.57	695	94	181	80
2048	1370	76.3	52.9	25.83	4.9	27.72	0.56	718	94	183	80
2206	1341	76.6	53.2	28.01	4.6	27.72	0.66	741	97	186	81
2345	1277	76.6	53.6	29.51	4.4	27.72	0.68	757	100	189	81
2500	1162	76.6	54	29.8	4.1	27.72	0.66	763	100	191	82
2664	733	76.6	55.3	22.35	4.2	27.72	0.72	706	101	190	83

80-20 BLEND

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
102	38.8	102	107	40.3	45.5	6.40	6.09	0.444	0.427	1592	4.3
110	43.2	110	113	44.3	48.1	6.70	6.42	0.437	0.426	1749	2.2
120	47	120	122	48.1	51.9	7.30	6.47	0.434	0.424	1898	4.2
127	50.9	127	129	51.9	55.8	7.80	6.53	0.441	0.432	2049	3.7
132	54.7	132	134	55.7	60.6	8.50	6.46	0.459	0.451	2197	4.6
133	58.7	133	135	59.5	64.1	9.00	6.54	0.481	0.474	2349	3.2
130	62.6	130	131	63.3	65.4	9.10	6.85	0.504	0.499	2500	2.6
92	66.9	92	92	67.2	53.5	7.50	8.93	0.583	0.58	2651	0.7

RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Temp deg F
1592	1480	68.7	52.9	18.97	5.3	27.74	0.39	566	75	169	73
1749	1426	68.7	53.2	21.65	5.4	27.74	0.43	644	84	178	74
1898	1426	68.7	53.8	24.24	5.3	27.74	0.55	689	86	176	75
2049	1392	69	54.1	25.93	5.1	27.74	0.63	711	88	179	77
2197	1350	69	54.4	28.11	4.8	27.74	0.55	733	85	181	77
2349	1272	69.3	54.6	29.41	4.4	27.74	0.72	749	92	184	79
2500	1160	69.3	55	29.8	4	27.74	1	758	94	187	80
2651	769	69.3	56.2	23.34	4.2	27.74	0.66	696	94	184	80

100%RME

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %
101	39.7	101	103	40.4	47.4	6.40	6.16	0.467	0.459	1590	2.3
109	43.6	109	111	44.4	51.3	7.00	6.26	0.469	0.46	1747	1.1
118	47.4	118	120	48.2	55.4	7.50	6.29	0.469	0.461	1898	0.9
125	51.2	125	127	52	60.2	8.20	6.26	0.482	0.474	2051	0.8
130	54.9	130	132	55.8	63.4	8.60	6.37	0.489	0.482	2197	0.7
131	58.8	131	133	59.6	67.3	9.10	6.43	0.513	0.506	2350	1
128	62.8	128	130	63.6	68.9	9.40	6.71	0.536	0.53	2504	1.3
88	67.1	88	88	67.5	53.2	7.20	9.28	0.606	0.603	2658	0.5

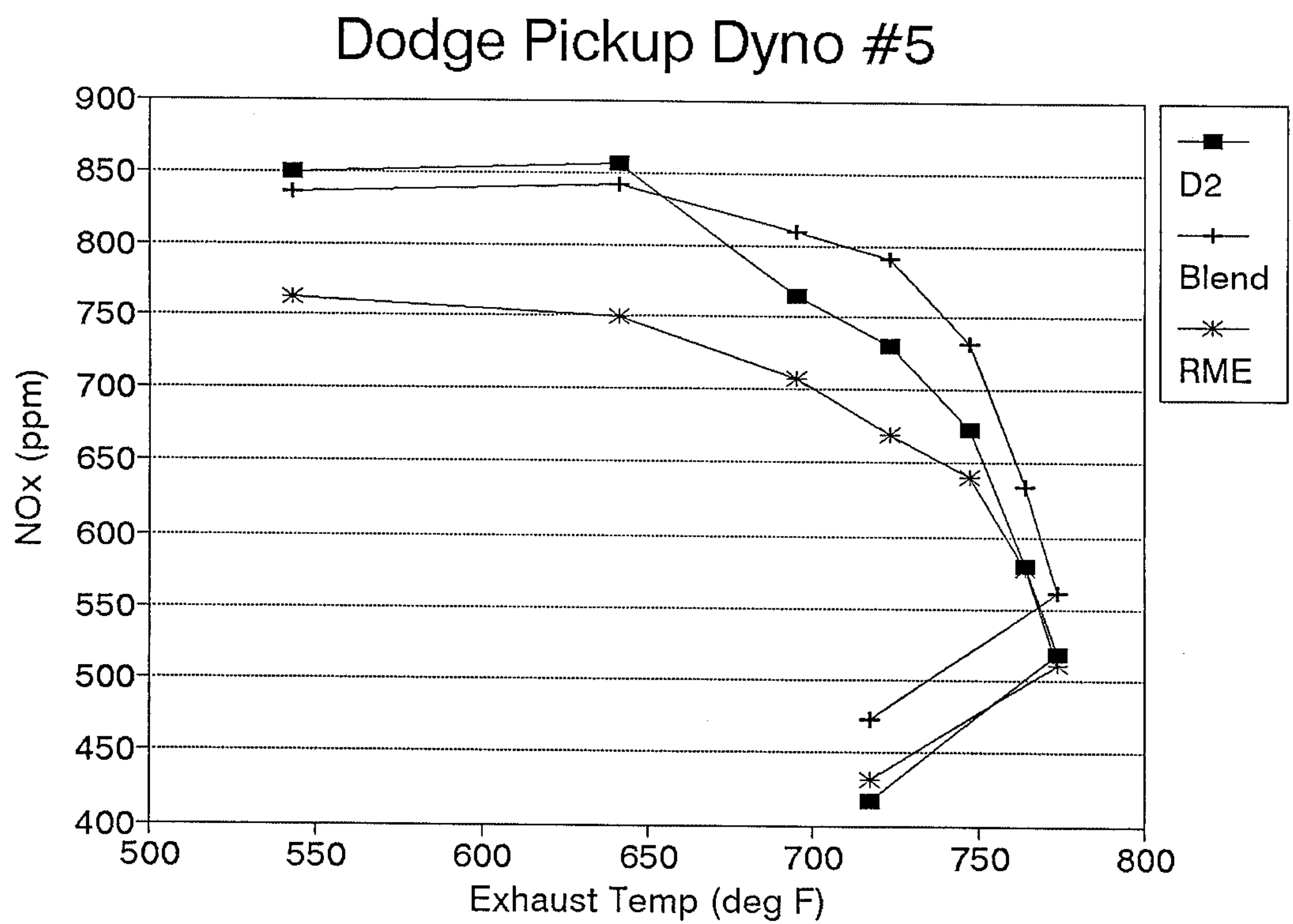
RPM	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Temp deg F
1590	1433	73.4	50.7	17.8	5.1	27.74	0.52	532	77	176	75
1747	1407	73.4	51.7	20.3	5.0	27.74	0.48	619	87	177	76
1898	1399	73.4	52.5	22.6	4.7	27.74	0.53	665	89	178	77
2051	1368	73.4	53.4	24.3	4.4	27.74	0.64	691	90	181	78
2197	1324	73.4	53.5	26.23	4.3	27.74	0.59	717	95	184	79
2350	1250	73.4	54	27.62	4.0	28.21	0.62	731	101	186	80
2504	1145	73.4	54.4	28.1	3.7	27.74	0.69	739	98	189	80
2658	733	73.1	55.8	21.5	3.5	27.74	0.7	685	104	185	80

Snap Idle Test

Diesel	Blend	RME
11.7	10.7	8.5
11.2	10.8	9.2
12.1	10.4	8.5
11.7	10.6	8.7

Cyl #	COMPR	VOP
1	480	3450
2	485	3450
3	485	3500
4	485	3500
5	490	3350
6	500	3350

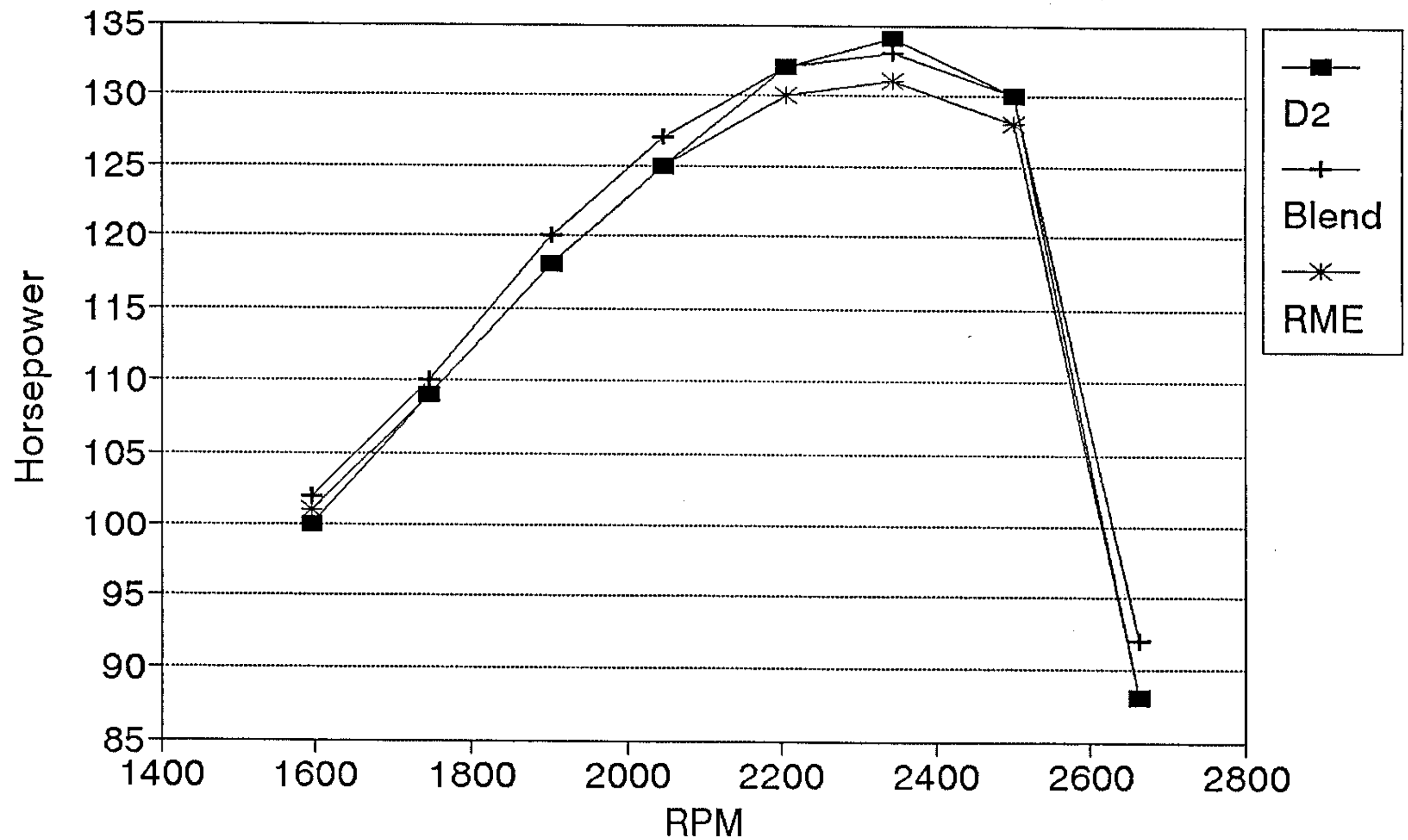
RPM	Exhaust Temp	Oxygen ppm	%CO	CO2 ppm	NOx ppm
		BLEND			
1600	543	8.9	9.0	306	850
1750	641	9.4	8.6	294	857
1900	695	9.8	8.3	216	764
2050	723	10.1	8.1	193	729
2200	747	10.2	8.0	183	672
2350	764	10.3	7.9	177	580
2500	774	10.6	7.7	171	518
2650	717	11.8	6.8	141	417
		100% RME			
1600	500	8.5	9.3	322	836
1750	611	9.1	8.8	312	842
1900	669	9.4	8.6	212	810
2050	701	9.7	8.4	195	791
2200	732	9.8	8.3	194	731
2350	747	10.0	8.1	193	633
2500	756	10.2	8.0	187	561
2650	714	11.2	7.2	170	472
		100% DIESEL			
1600	576	7.2	10.2	486	762
1750	661	8.0	9.6	343	749
1900	703	8.4	9.3	260	707
2050	731	8.6	9.2	236	669
2200	756	8.7	9.1	231	640
2350	774	8.8	9.0	229	578
2500	781	9.1	8.8	226	511
2650	737	10.1	8.1	201	431



Dodge Pickup Dyno #5
900
850
800
750
700
650
600
550
500
450
400
NOx (ppm)
500
550
600
650
700
750
800
Exhaust Temp (deg F)
D2
Blend
RME

Dodge Pickup Dyno #5

Horsepower vs RPM



1992 Dodge Dynamometer Test #6, October 5, 1995, 75,737 miles, 1,545 hours

100% RME Run #1

VehPwr Hp	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F
101	101	102	40.2	55.4	7.6	5.21	0.55	0.541	1596	0.7	1429	60	50.5	16.88	30.41	0.37	595	52	170
112	112	114	44	59.9	8.2	5.28	0.535	0.526	1750	0.2	1448	60	52	19.37	30.41	0.41	620	54	173
120	120	122	47.7	67.3	9.2	5.1	0.559	0.55	1896	0.1	1436	60.3	52.9	22.05	30.41	0.27	646	55	177
125	125	127	51.7	71.5	9.8	5.19	0.57	0.561	2052	0	1382	60.3	53.8	24.24	30.41	0.38	657	55	177
130	130	132	55.4	74.7	10.2	5.34	0.573	0.565	2199	0.2	1338	60	54.9	26.23	30.41	0.55	675	57	176
131	131	133	59.1	79.1	10.8	5.39	0.602	0.595	2350	0.4	1260	60.3	55.6	27.72	30.41	0.51	685	60	176
127	127	129	62.9	80.8	11.1	5.63	0.634	0.628	2500	1.4	1145	60	56.3	28.21	30.41	0.59	691	60	178
90	90	90	66.7	65.4	8.899999	7.44	0.725	0.723	2651	1.8	759	60.3	57.5	21.65	30.41	0.63	634	60	173

100% RME Run #2

VehPwr Hp	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F
103	103	105	40.5	54.2	7.4	5.33	0.527	0.514	1596	0.8	1458	60	51.5	16.48	30.41	0.31	507	55	168
112	112	115	44.4	50.6	6.9	6.25	0.452	0.441	1750	0.5	1448	60.3	52.3	18.97	30.41	0.35	571	56	174
117	117	120	48.2	54.2	7.4	6.34	0.461	0.45	1901	0.3	1399	60.3	53.2	21.65	30.41	0.34	615	54	179
124	124	127	52	58	7.9	6.4	0.468	0.458	2049	0.3	1365	60	54.1	23.84	30.41	0.53	645	56	175
132	132	135	55.8	63.1	8.600001	6.31	0.479	0.468	2198	0.4	1355	60.3	55.2	26.13	30.41	0.51	665	57	175
130	130	133	59.6	67	9.2	6.37	0.515	0.505	2351	1.5	1245	60	55.8	27.62	30.41	0.5	680	58	174
128	128	130	63.4	67.9	9.3	6.7	0.533	0.523	2499	18.2	1148	60	56.3	27.92	30.41	0.62	689	62	175
91	91	91	67.2	55.4	7.6	8.78	0.612	0.606	2650	2.6	762	60.3	57.4	21.25	30.41	0.79	634	67	173

20%RME/80%D2 Run #1

VehPwr Hp	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F
110	110	112	40	43.9	6.1	6.45	0.398	0.391	1598	2.3	1570	53.9	52.6	19.86	30.41	0.33	597	49	167
120	120	122	43.9	50.3	7	6.17	0.419	0.412	1752	1.8	1558	53.9	53.4	22.55	30.41	0.43	639	51	174
126	126	128	47.6	53.2	7.4	6.34	0.423	0.417	1901	2.3	1502	53.9	54.2	25.23	30.41	0.5	672	51	179
139	139	141	51.6	57	7.9	6.41	0.41	0.404	2059	4.3	1534	53.9	55.5	26.92	30.41	0.62	689	56	173
139	139	140	55.1	62.5	8.7	6.27	0.451	0.445	2201	4.1	1426	53.9	56	29.01	30.41	0.57	702	56	175
139	139	141	58.8	65.7	9.100001	6.37	0.472	0.467	2346	3.7	1341	53.9	56.5	30.6	30.41	0.55	714	57	176
135	135	136	62.7	67	9.3	6.68	0.496	0.492	2502	4.3	1216	53.9	57.2	30.9	30.41	0.71	720	58	175
92	92	92	66.7	52.6	7.3	9.140001	0.572	0.572	2662	1.3	772	53.9	58.5	23.44	30.41	0.54	685	60	173

20% RME/80% D2 Run #2

VehPwr Hp	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F
107	107	109	40.2	44.9	6.2	6.34	0.419	0.412	1599	1.9	1519	54.2	52.2	18.47	30.43	0.44	517	52	167
117	117	119	44	48.7	6.8	6.39	0.418	0.411	1750	1.2	1512	54.2	53.2	21.06	30.43	0.46	581	54	172
125	125	128	47.7	52.9	7.3	6.39	0.422	0.414	1900	0.9	1497	54.2	53.9	23.74	30.43	0.53	629	55	181
129	129	131	51.3	55.8	7.7	6.54	0.432	0.427	2040	0.8	1429	54.2	54.8	25.83	30.43	0.45	656	55	174
137	137	139	55.5	60.9	8.5	6.46	0.445	0.438	2207	0.9	1404	54.2	55.6	28.31	30.43	0.43	687	57	175
136	136	138	59.1	63.8	8.899999	6.58	0.468	0.462	2350	1.3	1309	54.2	57.7	29.7	30.43	0.53	704	60	175
133	133	134	62.8	65.7	9.100001	6.81	0.494	0.489	2499	1.9	1199	54.2	56.8	30.2	30.43	0.67	712	63	175
94	94	94	66.6	53.2	7.4	8.99	0.565	0.564	2651	1	794	54.2	57.8	22.94	30.43	0.68	659	62	173

100% D2 Run #1

VehPwr Hp	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F
103	103	105	40.1	56.1	7.8	5.03	0.543	0.532	1591	1.8	1470	66.1	50.1	18.47	30.39	0.32	623	58	175
112	112	114	44.1	60.9	8.5	5.11	0.545	0.535	1749	0.8	1446	66.1	51.7	20.86	30.39	0.29	653	57	172
120	120	122	48.1	65.4	9.100001	5.18	0.544	0.534	1905	0.7	1426	66.1	52.7	23.64	30.39	0.49	670	57	177
127	127	129	51.8	71.5	10	5.11	0.563	0.552	2053	0.6	1399	66.1	53.5	25.83	30.39	0.51	683	63	176
134	134	136	55.6	76.6	10.7	5.12	0.571	0.561	2204	1.7	1375	66.1	54.7	28.21	30.39	0.47	700	60	175
136	136	138	59.4	79.1	11	5.29	0.583	0.573	2353	2.9	1304	66.1	55.2	30	30.39	0.52	712	65	177
132	132	134	63.1	81.4	11.3	5.5	0.615	0.607	2502	2.4	1189	66.1	55.8	30.5	30.39	0.55	718	62	177
95	95	96	66.8	64.4	9	7.41	0.677	0.674	2649	1.3	801	66.1	57.2	22.94	30.39	0.8	649	62	173

100% D2 Run #2

VehPwr Hp	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F
104	104	106	40.6	50.3	7	5.64	0.486	0.473	1597	2.2	1468	66.1	50.8	17.97	30.39	0.41	547	59	168
112	112	115	44.5	55.8	7.8	5.57	0.498	0.484	1748	1.1	1451	66.1	51.8	20.76	30.39	0.48	602	60	181
119	119	122	48.3	61.2	8.5	5.52	0.516	0.502	1901	0.8	1411	66.1	53	23.44	30.39	0.48	633	57	175
126	126	129	52.2	67	9.3	5.45	0.531	0.518	2051	0.8	1389	66.1	53.9	25.63	30.37	0.45	660	58	175
133	133	136	55.9	72.1	10	5.42	0.542	0.528	2199	0.8	1368	66.1	54.9	28.11	30.39	0.49	682	63	175
136	136	140	59.7	75.6	10.5	5.53	0.554	0.541	2347	1.1	1311	66.1	55.8	29.7	30.39	0.61	697	63	174
131	131	134	63.6	77.5	10.8	5.76	0.591	0.578	2501	1.2	1182	66.1	56	30.3	30.39	0.76	710	64	175
83	83	84	67.7	62.2	8.7	7.73	0.745	0.736	2664	0.5	698	66.1	57.5	21.85	30.39	0.75	677	64	173

~~BLEND1~~ 92 Dodge 101 K miles

Dyno Test.

VehPwr Hp	R1 Spd MPH	R1 Pwr Hp	V Cpwr Hp	V CSpd MPH	Fuel M lbs/hr	Fuel V gal/hr	Econ MPG	VBSFC lb/Hphr	CBSFC lb/Hphr	RPM	Opacity %	Torque lb-ft	Fuel T Tank F	Oil P psi	MAP InHg	Fuel P psi	Baro P InHg	Blowby cfm	Exh T deg F	Inlet Air Temp F	Coolant Temp F	Fuel Tem deg F
blend1																						
80	29.7	80	80	30	38.8	5.4	5.45	0.487	0.482	1599	6[illegible]8	1504	52.8	52.6	13	0	30.09	0.29	0	59	0	0
90	32.5	90	91	32.9	41.7	5.8	5.56	0.462	0.457	1752	33.8	1556	53.1	53	15.19	0	30.09	0.3	0	69	0	0
100	35.3	100	101	35.6	42.9	6	5.85	0.429	0.425	1901	17	1587	52.8	53	17.58	0	30.09	0.38	0	77	0	0
107	38	107	108	38.4	44.5	6.3	6.08	0.416	0.411	2048	10.8	1580	52.8	53.4	18.87	0	30.07	0.42	0	88	0	0
115	40.6	115	116	41.1	48.1	6.7	6.02	0.419	0.414	2194	8.399999	1580	52.8	53.2	21.16	0	30.09	0.44	0	94	0	0
121	43.4	121	123	44.1	52.9	7.4	5.85	0.437	0.431	2350	7.4	1560	52.8	53.2	23.04	0	30.09	0.45	0	96	0	0
129	46.4	129	131	47	54.8	7.7	6.03	0.425	0.419	2507	8.5	1558	52.8	53.9	25.03	0	30.09	0.5	0	96	0	0
134	49	134	136	49.6	59	8.3	5.92	0.441	0.435	2647	8.600001	1531	52.8	53.9	26.52	0	30.09	0.46	0	100	0	0
blend2																						
111	39.8	111	113	40.4	47.1	6.6	6.02	0.424	0.417	1599	8.7	1565	53.1	51.5	19.27	0	30.07	0.49	0	89	0	0
122	43.6	122	124	44.3	51	7.2	6.1	0.417	0.41	1755	6.7	1570	53.1	52.4	22.35	0	30.07	0.48	0	95	0	0
129	47.4	129	131	48.2	53.2	7.5	6.35	0.413	0.407	1906	6.1	1521	53.1	53.1	25.03	0	30.07	0.6	0	100	0	0
136	51	136	138	51.7	59	8.3	6.16	0.432	0.426	2048	6.5	1499	53.1	54.2	26.72	0	30.07	0.6	0	99	0	0
144	54.8	144	146	55.6	60.9	8.5	6.41	0.423	0.418	2199	7.6	1470	53.1	54.7	28.91	0	30.07	0.45	0	100	0	0
145	58.1	145	147	58.8	63.4	8.899999	6.53	0.438	0.432	2330	9.399999	1397	53.1	55.6	29.9	0	30.07	0.41	0	100	0	0
142	62.4	142	143	63.1	66	9.3	6.74	0.466	0.462	2498	13.3	1270	53.1	56.3	30.6	0	30.07	0.99	0	100	0	0
91	66.7	91	91	67	48.4	6.8	9.82	0.532	0.529	2651	6.3	764	53.1	57.6	21.16	0	30.07	0.64	0	104	0	0
blend3																						
111	39.8	111	113	40.5	45.2	6.3	6.28	0.407	0.4	1599	8.600001	1563	53.4	50.7	18.87	0	30.07	0.37	0	97	0	0
122	43.6	122	124	44.3	49.3	6.9	6.3	0.404	0.398	1752	6.4	1568	53.4	51.6	22.05	0	30.07	0.34	0	101	0	0
129	47.3	129	131	48.1	53.5	7.5	6.3	0.414	0.407	1900	5.9	1531	53.7	52.6	24.63	0	30.07	0.37	0	100	0	0
137	51.1	137	139	51.9	58	8.100001	6.28	0.424	0.418	2050	5.7	1499	53.7	53.8	26.52	0	30.07	0.5	0	100	0	0
144	54.8	144	146	55.6	61.8	8.7	6.32	0.43	0.424	2198	6	1470	53.7	54.3	28.51	0	30.07	0.57	0	104	0	0
144	58.8	144	146	59.5	64.4	9	6.51	0.446	0.441	2351	7	1375	53.9	55.3	29.61	0	30.07	0.64	0	104	0	0
142	62.6	142	144	63.4	67	9.399999	6.66	0.471	0.465	2503	8.899999	1272	53.9	56.1	30.7	0	30.07	0.51	0	103	0	0
92	66.7	92	92	67.1	50	7	9.520001	0.545	0.542	2651	6.7	769	53.9	57.3	21.55	0	30.07	0.61	0	103	0	0
rme1																						
109	39.9	109	110	40.4	46.8	6.4	6.21	0.43	0.424	1599	5.7	1529	52.8	52.1	18.37	0	30.06	0	0	95	0	0
118	43.7	118	120	44.4	50	6.9	6.37	0.423	0.416	1753	2.3	1516	52.5	52.9	20.86	0	30.06	0.01	0	99	0	0
123	47.3	123	125	48	55.4	7.6	6.22	0.45	0.444	1898	1.1	1458	52.5	53.7	22.65	0	30.06	0.58	0	98	0	0
129	51.2	129	131	51.9	59.6	8.2	6.26	0.461	0.455	2051	0.9	1414	52.5	54.6	24.44	0	30.06	0.48	0	99	0	0
136	54.9	136	138	55.6	64.4	8.8	6.21	0.472	0.466	2197	1	1392	52.5	55	26.52	0	30.06	0.04	0	101	0	0
137	58.8	137	139	59.5	67.9	9.3	6.31	0.496	0.49	2351	1.3	1306	52.5	56	27.92	0	30.06	9.00E-02	0	99	0	0
133	62.5	133	134	63.3	69.2	9.5	6.58	0.522	0.515	2500	1.7	1189	52.5	56.5	28.21	0	30.06	0.01	0	100	0	0
79	67.1	79	80	67.3	51.3	7	9.54	0.647	0.645	2660	1	662	52.5	57.9	19.07	0	30.06	0	0	101	0	0
rme2																						
107	39.9	107	108	40.5	49.7	6.8	5.86	0.466	0.459	1601	3.1	1497	52.8	50.1	17.58	0	30.06	0	0	97	0	0
116	43.7	116	118	44.4	51	7	6.26	0.438	0.432	1753	1.5	1490	52.5	51.4	20.16	0	30.06	0	0	101	0	0
123	47.4	123	125	48.1	58.3	8	5.93	0.474	0.467	1900	1.2	1455	52.5	52.4	22.45	0	30.06	0	0	102	0	0
130	51.3	130	132	52.1	59.6	8.2	6.28	0.457	0.451	2056	1.1	1424	52.5	53.8	24.34	0	30.06	0	0	101	0	0
136	54.7	136	138	55.5	64.1	8.8	6.23	0.471	0.464	2192	1.2	1394	52.5	54.5	26.52	1.6	30.06	0.01	0	102	0	0
136	58.8	136	138	59.6	67.6	9.3	6.35	0.495	0.489	2355	1.3	1299	52.8	55.5	27.52	0	30.06	0	0	103	0	0
134	62.7	134	135	63.3	69.9	9.600001	6.54	0.523	0.517	2502	2.1	1194	52.8	56.3	28.11	0	30.06	0	0	102	0	0
81	67	81	81	67.3	50.6	6.9	9.649999	0.628	0.626	2657	1	674	52.8	57.7	18.97	0	30.06	0	0	101	0	0
rme3																						
107	39.8	107	108	40.5	47.7	6.5	6.08	0.448	0.44	1596	3.4	1502	52.8	50.5	17.58	0	30.06	0	0	97	0	0
117	43.7	117	119	44.5	51.6	7.1	6.18	0.441	0.433	1754	1.8	1499	52.8	51.7	20.16	0	30.06	0	0	100	0	0
124	47.4	124	126	48.1	55.8	7.6	6.19	0.451	0.444	1898	1.4	1463	52.8	52.5	22.55	0	30.06	0	0	102	0	0
131	51.3	131	133	52.1	59.6	8.2	6.27	0.454	0.447	2053	1.3	1436	52.8	54	24.54	0	30.06	0	0	101	0	0
135	55.1	135	138	55.9	64.4	8.8	6.24	0.476	0.468	2206	1.3	1377	53.1	54.7	26.32	0	30.06	0.01	0	105	0	0
134	58.7	134	135	59.5	65.1	8.899999	6.59	0.487	0.48	2347	1.6	1275	53.1	55.6	26.92	0	30.06	0	0	100	0	0
65	63.6	65	65	63.9	40.4	5.5	11.49	0.625	0.622	2521	1.2	569	53.1	57.6	14.3	0	30.06	0	0	103	0	0
12	67.1	12	12	67.1	23.7	3.3	20.65	1.976	1.979	2644	1.3	100	53.1	59.1	7.34	0	30.06	0	0	101	0	0
rme4																						
105	39.9	105	107	40.5	47.4	6.5	6.14	0.45	0.443	1601	3.5	1480	53.7	51.6	17.18	0	30.06	0.48	454	88	0	0
116	43.8	116	118	44.4	48.7	6.7	6.55	0.419	0.414	1754	2.2	1487	53.7	53	19.86	0	30.06	0.45	538	94	0	0
126	47.6	126	127	48.2	52.6	7.2	6.61	0.417	0.412	1904	1.8	1482	53.9	53.8	22.55	0	30.06	0.5	596	99	0	0
130	51.1	130	132	51.8	59.3	8.100001	6.29	0.456	0.45	2047	1.6	1426	53.9	54.7	24.34	0	30.06	0.58	640	100	0	0

Malfunction? Metal

135	54.6	135	136	55.3	61.5	8.399999	6.48	0.457	0.451	2186	1.6	1382	53.9	55.4	26.13	0	30.06	0.48	668	100	0	0
136	58.8	136	137	59.5	65.7	9	6.53	0.483	0.478	2351	1.8	1294	54.2	56.2	27.52	0	30.06	0.51	692	99	0	0
134	62.6	134	135	63.2	67	9.2	6.82	0.5	0.495	2498	2.5	1199	54.2	56.7	28.31	0	30.06	0.76	701	98	0	0
77	67.1	77	77	67.3	50	6.8	9.8	0.647	0.646	2659	1.5	645	54.2	58.1	18.67	0	30.06	0.69	659	100	0	0
diesel1																						
104	40	104	0	0	43.9	6.1	6.5	0.422	0	1601	3.3	1460	56.6	51.9	17.58	0	30.06	0.44	481	92	0	0
118	43.7	118	0	0	47.4	6.6	6.58	0.401	0	1753	2	1514	56.6	52.6	21.16	0	30.04	0.47	565	98	0	0
127	47.5	127	0	0	54.5	7.6	6.22	0.429	0	1901	1.7	1499	56.6	53.4	24.34	0	30.06	0.49	632	102	0	0
136	51.2	136	0	0	57.7	8.100001	6.33	0.424	0	2051	1.5	1490	56.8	54.4	26.82	0	30.06	0.43	682	100	0	0
143	55	143	0	0	61.5	8.600001	6.38	0.431	0	2204	1.7	1455	56.6	55	28.81	0	30.06	0.42	706	103	0	0
143	58.8	143	0	0	67	9.399999	6.27	0.467	0	2350	2.1	1365	56.8	55.9	30.1	0	30.06	0.62	723	100	0	0
141	62.6	141	0	0	67.6	9.5	6.61	0.479	0	2500	2.5	1265	56.8	56.5	30.9	0	30.04	0.71	738	101	0	0
84	66.9	84	0	0	45.2	6.3	10.58	0.536	0	2656	1.2	706	56.8	57.8	20.56	0	30.06	0.61	691	103	0	0
diesel2																						
111	39.9	111	113	40.6	41	5.7	6.95	0.37	0.364	1601	5.4	1556	57.1	49.6	19.27	0	30.06	0.46	599	103	0	0
119	43.6	119	121	44.4	48.1	6.7	6.48	0.404	0.397	1752	2.7	1529	57.1	50.7	22.35	0	30.06	0.48	655	104	0	0
129	47.4	129	131	48.1	52.9	7.4	6.4	0.41	0.403	1900	1.8	1526	56.8	52.1	24.83	0	30.04	0.39	689	104	0	0
136	51.1	136	138	51.9	58.6	8.2	6.23	0.432	0.425	2050	1.7	1487	56.8	53.3	26.72	0	30.06	0.39	708	105	0	0
142	55	142	144	55.8	60.6	8.5	6.48	0.427	0.42	2204	1.6	1446	57.1	54.2	28.71	0	30.04	0.58	723	103	0	0
143	58.7	143	145	59.6	66.7	9.3	6.29	0.465	0.458	2351	2	1368	56.8	55.1	30.1	0	30.04	0.64	736	104	0	0
142	62.6	142	144	63.4	66.3	9.3	6.74	0.466	0.461	2501	3	1272	56.8	55.8	31.1	0	30.04	0.82	746	101	0	0
89	66.8	89	89	67.2	50.3	7	9.479999	0.568	0.565	2652	1.3	742	56.8	57.1	21.06	0	30.04	0.82	699	105	0	0
diesel3																						
110	39.9	110	112	40.5	45.5	6.4	6.26	0.414	0.407	1601	5.1	1543	56.8	49.3	19.27	0	30.04	0.36	607	106	0	0
119	43.8	119	121	44.4	47.1	6.6	6.64	0.394	0.389	1754	2.4	1529	56.8	50.6	22.25	0	30.04	0.38	652	105	0	0
129	47.3	129	130	47.9	50	7	6.75	0.389	0.383	1893	1.6	1524	56.8	51.9	24.73	0	0	0.57	688	104	0	0
136	51.2	136	138	52	57.4	8	6.38	0.421	0.415	2053	1.5	1490	56.8	53.2	26.72	0	30.04	0.65	707	104	0	0
142	54.9	142	144	55.7	61.2	8.600001	6.41	0.43	0.424	2199	1.5	1453	56.8	54	28.71	0	30.04	0.73	727	104	0	0
144	58.7	144	146	59.5	64.4	9	6.5	0.447	0.441	2350	1.7	1375	56.8	54.9	30.2	0	30.04	0.81	739	105	0	0
141	62.6	141	143	63.3	66.7	9.3	6.71	0.471	0.466	2499	3	1265	56.8	55.7	30.9	0	30.04	0.63	746	104	0	0
78	67	78	79	67.2	45.5	6.4	10.51	0.581	0.579	2656	1.3	654	57.1	57.2	19.37	0	30.04	0.61	689	107	0	0

Appendix E

Slide show script

1. **Demonstration**
of the On-The-Road
Use of Biodiesel
IDWR Energy Division/University of Idaho

Cummins Powered 1992 Dodge

100,000 Mile On-Road Test

Contract No. DWR-92-03-81-102-6

2. ## Demonstration of the On-The-Road Use of Biodiesel

IDWR Energy Division/University of Idaho
Cummins Powered 1992 Dodge
100,000 Mile On-Road Test

(with Photo of Truck)

Contract No. DWR-92-03-81-102-6

3. **Principal Investigator**
Charles L. Peterson
Department of Biological
and Agricultural Engineering
University of Idaho

Project Manager
Gerald Fleischman
Idaho Department of Water Resources
Energy Division

4. **Objectives**

- Operate a pickup for 100,000 miles with a blend of 20% RME-80% Diesel
- Use an on-board mixing system and provide tank heating
- Use dynamometer testing to determine power, opacity and fuel economy of each fuel
- Conduct standard fuel characterization tests
- Compare regulated emissions: HC, CO, NOx and PM

5. **Test Vehicle**

- 1992 Dodge 2500 Pickup Truck
- Engine: 5.9 L, in-line 6 cylinder turbocharged and intercooled
- Bore and stroke: 102.0 x 120.0 mm
- Compression ratio 15.1:1
- Engine Rating: 160 hp at 2500 rpm

6. 1992 Dodge used in the 100,000 mile test. This photo was taken shortly after the vehicle was received from the dealer.

7. Another view of the 1992 Dodge shortly after delivery.

8. Front view of the 1992 Dodge vehicle.

9. The 1992 Ford and the 1992 Dodge on the grade above Kendrick, Idaho with a rapeseed field in the background

10. **On-Board Mixing**

- Blending Chamber (1.5 gal)
- Feed pumps for diesel and RME
- Float Switch Controls
  -Level 1 for diesel (80%)
  -Level 2 for RME (20%)

11. The fuel gauge for the vegetable oil tank, the hour meter, and the meters used to inform the operator that the diesel and the vegetable oil blending system was working.

12. The small tank added under the frame of the vehicle where the blending of the diesel and the vegetable oil took place.

13. The 1992 Dodge in the shop during the installation of the fuel tank and the mixing system.

14. **RME Tank Heating**

- Engine Coolant
- Circulation Pump for Positive Flow
- Block Heater for Engine Off Heating
- AC to DC Power Converter for Circulation Pump
  when the Engine is not running

15. A view of the tank added to the bed of the vehicle to carry the vegetable oil fuel.

16. Heat exchanger installed in the vegetable oil tank for heating the vegetable oil. Also, another view of the electrical coolant heater for use when the vehicle is parked.

17. A view of the tubing used to heat the vegetable oil tank to provide heat during the wintertime.

18. **RME Fuel**

- Dwarf Essex variety Winter Rapeseed oil expressed at the University of Idaho
- Transesterified with methanol and KOH
- The RME and commercial Diesel were blended on-board the test vehicle

19. A rape field in the Palouse country of Northern Idaho. Rapeseed is the crop that was used to produce the vegetable oil fuel called Biodiesel.

20. Close up of the rapeseed plant.

21. **Dwarf Essex Rapeseed Fatty Acid Composition**

♦ Palmitic (16:0)	2.2%
♦ Stearic (18:0)	0.9%
♦ Oleic (18:1)	12.6%
♦ Linoleic (18:2)	2.1%
♦ Linolenic (18:3)	8.0%
♦ Eicosenoic (20:1)	7.4%
♦ Behinic (22:0)	0.7%
♦ Erucic (22:1)	49.8%

22. University of Idaho Biodiesel reactor.

23. Biodiesel from rapeseed oil.

24. **Fuel Characterization**

- Viscosity: RME = 1.8 times 2-D
  20RME very similar to 2-D
- Pour Point:
  RME -15 C
  2-D -23 C
- Heat of Combustion:
  2-D is 5.6% greater than RME
- Flash Point:
  RME 179 C 2-D - 74C

25. The pickup was used to shuttle U of I and IDWR personnel around the northwestern US, move lightweight equipment and only minor trailer pulling; as a consequence, it's use was judged as light duty.

26. 1992 Dodge on its maiden voyage to Boise. Note the 55 gallon drum which was being delivered to the Idaho Department of Water Resources Energy Division. Also, note in the background the 1992 Ford, which was placed under test at the same time.

27. Governor Cecil Andrus pouring in the symbolic first gallon of Biodiesel fuel during the kick-off at the Idaho State Capitol Building in August 1992.

28. 1992 Dodge in Lewiston, Idaho, during one of its visits to Northern Idaho.

29. 1992 Dodge and 1992 Ford on exhibit at an energy program in Boise, Idaho.

30. The 1992 Dodge on a cold winter day on a trip to Butte, MT.

31. Second shot of 1992 Dodge during the trip to Butte, MT during very cold weather.

32. The 1992 Dodge at the Second Biomass Conference of the Americas in Portland, OR, August, 1995.

33. A second photo of the 1992 Dodge at the Second Biomass Conference of the Americas.

34. **Performance Parameters**

- Fuel Economy - 20.9 mpg for 97,748 miles
- Fuel mixture - 28% RME - 72 % 2-D (actual)
- Average speed - 49.2 mph based on hour meter

35. **Engine Oil and Oil Analysis**

- Chevron Delo Multigrade SAE 15W-40 oil
- Oil analysis completed by two commercial labs over the 4 years of tests
- Oil changes and oil samples at approximately 3,000 mile increments

36. **Engine Oil Analysis Results**

(average for test)

Iron, ppm		Aluminum, ppm	
Test Vehicle	8.0	Test Vehicle	2.2
Check Vehicle	8.5	Check Vehicle	2.4
Check Vehicle	20.0	Check Vehicle	5.4
Check Vehicle	76.3	Check Vehicle	5.7

37. **Engine Cylinder Compression**
(average for 6 cylinders)

Start	497 psi	sd - 7.4 psi
End	497 psi	sd - 4.7 psi

sd = standard deviation

38. **Valve Opening Pressure**
(average for 6 cylinders)

Start	3,520 psi	sd - 21.6 psi
End	3,525 psi	sd - 25 psi

The injectors were cleaned at 49,275 miles because of sticking caused by tank rust

sd = standard deviation

39. **Dynamometer Testing**

- Western States Caterpillar, Spokane, WA
- Dynamometer tests at:

1,470 miles	49,200 miles
10,470 miles	75,737 miles
20,300 miles	101,785 miles
32,630 miles	

- Full rack torque test with pre-programmed RPM's in the computer from 1600 to 2650 rpm in 150 rpm increments

40. **Dynamometer Test Results for Horsepower and Smoke Density**
(graph of results)

41. **Dynamometer Test Results**
- Power was reduced 4.96 % with 100RME and 1.47% less with 20RME compared to diesel
- Smoke Density was reduced 32% with 100RME and was increased 83% by 20RME compared to diesel

42. **Emissions Tests**
- 1994 pickup with 5.9 L Cummins diesel
- Tests conducted at the Los Angeles Metropolitan Transit Authority Emissions Test Facility, Los Angeles, Calif.
- Measured only regulated emissions:

-HC	-CO
-NOx	-PM

43. 1992 Dodge and 1994 Dodge taken en route to California for the emissions test in March 1994.

44. Second photo of 1992 Dodge and 1994 Dodge taken en route to California.

45. 1994 Dodge in foreground, 1992 Dodge in background shown on the beach near Los Angeles on the Pacific Ocean, taken in March of 1994, during the trip to the Los Angeles Metropolitan Transit Authority Emissions Test Facility.

46.

1994 Pickup Emissions Data, EPA Cycle
(no catalytic converter)
gm/mile

	HC	CO	NOx	CO_2	PM
Diesel	1.254a	4.497a	6.850a	698a	0.411a
20RME	1.002b	3.07b	6.600b	709a	0.353a
100RME	0.650c	2.08c	6.313c	704a	0.510a

47.

100,000 Mile Engine Tear Down

At 100,000 miles the engine was removed from the vehicle
and shipped to the Cummins factory for analysis

48. Nga Le and Jim Branner Jr. of the Cummins Technical Center who were instrumental in having Cummins complete the engine tear down and analysis at the conclusion of the test at 100,000 miles.

49. View of the engine components at Cummins, showing the head, the valves, the head gasket and some of the bearings. Each of the following pictures demonstrates the cleanliness of the engine and the small amount of wear that was noted by Cummins.

50. A closer view showing the cylinder ports and the valves and the general overall good state of the engine.

51. The crankshaft, camshaft, rocker pads, and other engine components again showing the cleanliness of the engine and the small amount of wear.

52. Close up of the valves.

53. Pistons, piston rings, and some other engine components.

54. Engine bearings. Cummins evaluated these as showing very little wear and reinstalled them in the engine, even after having 100,000 miles of use.

55. Close up of the head, showing the valve seats and valve ports, indicating the low amount of deposits in the engine after 100,000 miles.

56. Close up of cylinder parts showing how clean they were. Photo taken by Craig Chase.

57. Close up of cylinder showing how the cross hatching was still very evident. Photo taken by Craig Chase.

58. Engine oil pump, again this was judged to have very low wear.

59. A close up of the wear surface on the end of the crankshaft where the oil seal rides showing a small indentation caused by hardening of the seals.

60. View of the rear engine seal and its wear surface on the end of the crankshaft.

61. Close up of the same seal and wear surface.

62. View of the front housing on the engine showing the small amount of seepage that was occurring at the front main seal.

63. View of the injector pump with the cover removed, showing the varnish that had accumulated on the outside of the surfaces of the pump.

64. Closer view of that same pump showing the varnish. Pump tests showed normal fuel delivery at the conclusion of the test. The varnish, while undesirable, was not doing measurable harm at the time of this test.

65. **Tear Down Comments**

- Engine reflected light load condition
- It was generally characterized as in as good or better condition than would be expected when operated on diesel fuel
- Water pump bearing noisy (not fuel related)
- Injector pump had considerable varnish which was not thought to be affecting performance

66. **Tear Down Comments (cont'd)**

- Crankshaft seals had some tendency to harden with a resulting slight depression where they made contact with the crankshaft
- Rusting of the fuel filter attachment stud

67. **Conclusions**

- There was no indication of abnormal performance using the RME blend
- Fuel mixing system proved difficult to adjust to the exact mixture. It was low at the beginning and high at the end with an over-all average of 28 % RME and 72% diesel compared to the target of 20%
- Fuel tank rusting where mild steel was used was a problem resulting in fuel filter plugging

68. **Conclusions (cont'd)**

- Compared to diesel, smoke density was reduced 32 % with RME and 6.6 % with 20 RME
- RME produced 5% less power than diesel and 20 RME 1% less power than diesel.
- Fuel consumption was 4% higher than diesel with RME and 1.8% higher with 20 RME. Injector Coking was low throughout the test

69. **Emission Test Conclusions**

Compared to Diesel, 20RME Fuel
- Decreased:
  - HC by 19%
  - CO by 28%
  - NOx by 3.4 %
  - PM by 9.0%

70. **Emission Test Conclusions**

Compared to Diesel, 100 RME Fuel
- Decreased:
  - HC by 53%
  - CO by 48 %
  - Nox by 14%
- and Increased:
  - PM by 14%

71. **Tear Down Conclusions**

- Light Load Condition was evident
- Engine condition was generally characterized as good or better than normally expected with diesel fuel
- Engine parts were clean with little wear
- Hardening of crankshaft seals caused a slight depression at their contact points on the crankshaft
- Fuel pump showed varnish but was otherwise in good condition

72. **Acknowledgments**

- Idaho Department of Water Resources for financial support and for operating the vehicle and observing its performance
- Personnel at Los Angeles Metropolitan Transit Authority for conducting the Emissions Tests
- USDA-ARS for financial support
- Personnel at Cummins for their assistance with the engine final inspection
- Craig Chase, consultant to DOE for encouragement and support

73. The three Biodiesel fueled pickups; the 1994 Dodge, 1992 Dodge, and the 1992 Ford at a meeting at Simplot, Caldwell, Idaho in March of 1994. This was at one of the early meetings on the development of used Hydrogenated Soy Ethyl Ester produced from used french fry oil and ethanol from the Simplot french fry plant.

74. The four Biodiesel fueled pickups at Yellowstone National Park at a Biodiesel conference.

75. **Disclaimers**

Methanol is a hazardous material and can cause sickness or death when improperly handled. Methanol is also a serious fire hazard. Those handling methanol should be certain that all handling and storage equipment meets local fire codes. Users should obtain, keep handy, and follow the provisions of the applicable MSDS forms for Methanol and all other chemicals used.

76. **Disclaimers**

Catalysts used in making Biodiesel are also toxic and should be handled with care. Consult the suppliers MSDS forms for applicable precautions.

77. **Disclaimers**

Biodiesel is an experimental product and the toxicological properties have not been thoroughly investigated. Universal precautions should be observed in all situations.

78. **Road Taxes**

Users of Biodiesel should be aware that any private use in an on-road vehicle, whether purchased or privately produced from local materials, is subject to both federal and state road tax. In Idaho this would amount to 24.3 cents per gallon federal tax and 25 cents per gallon state tax. In Idaho, biodiesel is included in the law which allows up to 10% alternative fuel use without being subject to road tax. Check with the state tax commission for interpretation of the law in a specific case. Biodiesel fuel producers and users should contact local IRS offices and state tax agencies for road tax amounts and reporting requirements.

79. **Warranty Issues**

Biodiesel (methyl or ethyl ester of plant oils or animal fats) is a new fuel which is being tested under a wide range of conditions including both neat and blended with petrodiesel. Users of this fuel should be aware, however, that currently there is no fuel specification for Biodiesel and, therefore, engine manufacturers' published fuel specification requirements assume warranty liability for failure of components or emission certification traceable to the fuel. Non-fuel related warranty issues are not affected by the use of Biodiesel.