General Motors
Public Policy Center

September 3, 1998
FE-6235

Ms. Deborah K. Wood
Assistant Director, Fuels and Energy Division
Office of Mobile Sources
U.S. Environmental Protection Agency
401 K Street, S.W.
Washington, DC 20460

Dear Ms. Wood:

Re: Fuel Pump Failures During Federal Phase II RFG Testing in Village of Elk Grove, IL, Fleet Vehicles

At the request of your office, General Motors fuel systems personnel examined three fuel pumps that failed during the Federal Phase II RFG test program. The three fuel pumps were from General Motors vehicles operated by the Village of Elk Grove, IL, and were shipped to us from that test fleet.

Two of the pumps were General Motors Delphi rollervane pumps. We were informed that these two pumps were from Chevrolet Caprice police vehicles, a 1995 model with 85,000 miles and a 1996 model with 56,000 miles at the time of failure. It is not known if these pumps were the original production pumps supplied when the vehicle was assembled, but these mileages would indicate that they probably are.

Both rollervane pumps failed because of severe corrosion of the positive brush shunt wire. In both pumps the wire had corroded away entirely leaving the brush spring to carry the pump current, causing the spring to fail eventually because of overheating. The first pump received, from the 1995 vehicle, also displayed severe wear of the copper commutator. The commutator on the other pump was also worn abnormally but not as severely.

The severe positive shunt wire corrosion in the two pumps is typical of previously observed field results during longer-term exposure to gasoline containing reactive sulfur compounds (most often a sulfide, but not exclusively). These compounds corrode copper and, if present, would not allow the gasoline in question to meet ASTM standards for copper strip corrosion. The black deposits on the commutators of both pumps also can be attributed to copper corrosion by reactive sulfur compounds but this was not verified by analysis. The commutator wear was probably also caused by copper corrosion; high levels of peroxides in fuel also can cause the same type of commutator wear, but do not usually cause shunt wire failure. Our conclusion is that a high level of corrosion probably was present in both of these rollervane pumps at the start of the Phase II RFG testing, and the failures are coincidental to the use of reformulated gasoline.

The third pump was a large capacity diaphragm pump used on carbureted fuel systems, which was removed from a 1981 Chevrolet Step Van at 66,000 miles. The diaphragm pump has the markings E L5 and 40987 but is of unknown manufacture, and is not the original equipment component, in our estimation. This pump showed no obvious signs of failure except for an oil leak and possibly an extruded seal. The oil leak was not caused as a result of fuel composition. The extruded seal could be the result of excessive swell; which may be caused by the presence of oxygenates or by excessively high aromatic content or a combination. The apparent extrusion could also be due to an assembly problem. If the seal in question were not sealing properly, it would cause internal fuel leakage and siphoning of the fuel back to the fuel tank. In the most extreme case, the pump would have either reduced or no delivery capacity. If the seal extruded because of excessive swell, this could have occurred in the short duration of the Phase II RFG testing. However, it seems more likely that the failures of both the rollervane and the diaphragm pumps was coincidental to the Phase II RFG use and not related to the use of Phase II RFG.

If I can provide further information, please don't hesitate to call me at (313) 556-7723.

Sincerely,

Gerald J. Barnes, Manager
Clean Fuels Activities

General Motors Corporation

General Motors Building *3044 West Grand Boulevard* *Detroit, Michigan 48202*
Mail Code 482-112-257 *Facsimile # (313) 556-9002* *Phone # (313) 556-7723*

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September 23, 1998
FE-6239

Ms. Deborah K. Wood
Assistant Director, Fuels and Energy Division
Office of Mobile Sources
U.S. Environmental Protection Agency
401 K Street, S.W.
Washington, DC 20460

Dear Ms. Wood:

Re: Fuel Pump Failures During Federal Phase II RFG Testing in Houston, TX Fleet Vehicles

General Motors fuel systems personnel examined four fuel pumps that failed during the EPA Federal Phase II RFG test program in Houston, TX. All four fuel pumps were of in-tank twin turbine design from 1993 Chevrolet S10 pickups; these vehicles operated on both Phase II RFG test fuel and on the control fuel in the Houston test program, as shown below.

Vehicle #	Mileage	Fuel
1047	82,553	Phase II RFG
1051	72,771	Control
1113	81,998	Control
1249	86,589	Control

Upon receipt, all pumps were checked for free rotation and electrical conductivity before disassembly. No indication of binding was seen in any of the four pumps. However, resistance across the power leads was high for all four samples. This is consistent with the high wear observed on the pump motor commutator upon disassembly. The brushes showed normal wear, however. In addition, the aluminum housing of the pump was covered with fuel gum deposits, imparting a gold color to the pump housing.

The heavy commutator wear coupled with normal brush wear suggest that all four pumps failed due to operation on peroxidized (sour) fuel. The gum deposits on the pump housing are also consistent with this conclusion. This type of failure usually occurs quite quickly, depending on the level the peroxides reach in the fuel in use. Since the failures occurred in both the Phase II RFG and the control fuels, they seem more likely related either to the fuel dispensing system or to vehicle operating factors leading to oxidation of the fuel, rather than to the base composition of either fuel.

General Motors Corporation

General Motors Building 3044 West Grand Boulevard Detroit, Michig
Mail Code 482-112-257 Facsimile # (313) 556-9002 Phone # (313)

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Peroxidized fuel can result from a number of factors, including poor oxidation stability of the base fuel, long fuel storage time, high storage temperatures, contact with air (such as in a partially filled vehicle or storage fuel tank), or a combination of these factors. Peroxides form by a free radical chain reaction and tend to increase in concentration once present in fuel storage tanks if the right reaction conditions continue to exist. This could lead to a "carry-over" effect in fuel storage systems, if the conditions for peroxide formation continue to exist, even with uncontaminated batches of new fuel. Contact with copper catalyzes the oxidation reaction, and the peroxides produced are very corrosive to copper such as the pump commutator in the failed pumps.

As we discussed with Mr. Haslett, we would suggest that the fleet operator check the current batches of Phase II RFG and control fuels for peroxide, washed gum and acid levels. Levels of peroxides (above 50 ppm by ASTM D 3703) would be of concern, as would washed gum levels above 10 mg/100 ml (ASTM D 381). High acid levels (above about 10 ppm by ASTM D1613) indicate the fuel has probably oxidized even if peroxide levels are relatively low. If high peroxide levels are found in the fuels used in the Houston fleet, it probably is advisable to dispose of the fuel and take steps to reduce the factors that lead to fuel oxidation. The operator may want to consider use of an oxidation inhibitor such as Sta-bil, particularly during the higher temperature summer months.

If I can provide further information, please don't hesitate to call me at (313) 556-7723.

Sincerely,

Gerald J. Barnes

Gerald J. Barnes, Manager
Clean Fuels Activities

c: Lawrence Haslett, EPA

General Motors Corporation

General Motors Building 3044 West Grand Boulevard Detroit, Michigan 48202
Mail Code 482-112-257 Facsimile # (313) 556-9002 Phone # (313) 556-7723