soot and particles that are exhausted from an engine. The particulate trap does not change the hydrocarbons, the NO_x, or the carbon monoxides. However, the particulate levels will drop from 0.33 to 0.05 grams per hour. The negative impact of the particulate trap is that it requires a little more space than a standard muffler. The particulate trap, installed, costs about $4,000 to $8,000 per vehicle. Positive regeneration is also required.

CNG Programs

There are 2 CNG programs: a dual fuel, pre-chamber type engine, and a direct injection engine. The fuel tank will require four times the volume required for a diesel. The tank will also add from 2,500 to 5,000 pounds to the weight of the vehicle. A gas pressure regulators will be required as well as special fittings for refueling.

ALTERNATIVE FUEL ENGINES IN AUTOMOBILES

Richard Simmons, *Chrysler Corporation*

This paper provides a brief overview of Chrysler Corporation's efforts in the development of a flexible fuel vehicle (FFV) and how such a vehicle (cars and light trucks) will affect the equipment mechanic.

An FFV is a car or truck designed to operate equally well on gasoline or M85, 85% methanol and 15% gasoline, or any mixture of gasoline and M85. For example M20 is 20% methanol and 80% gasoline, M50 is 50% methanol, and so on. An FFV can be fueled with either M85 or gasoline, as well as the intermediate blends that will result from topping off a partially full tank with the either fuel. Methanol was selected since it can reduce smog formation; is an alternative energy source; and may be mandated by law, perhaps in fleets first.

Why was M85 selected rather than pure methanol? There are three reasons: the 15% of gasoline provides flame luminosity for safety, since pure methanol has an almost invisible flame; it provides the ability to start at lower temperatures than would be possible with pure methanol; it gives M85 the distinctive order and taste of gasoline, a safety factor.

There will be no readily discernable difference between a gasoline vehicle and an FFV. However, an FFV will have some additional systems that a gasoline only car does not have and it will have some material differences.

Systems. The FFV will have a sensor to detect the percentage of methanol in the fuel and a computer program to adjust the fuel delivery schedule, the spark advance schedule, and other engine operating parameters for the specific fuel mixture. If you pump M85 into an FFV, it adjusts itself to run properly on that fuel. If you pump gasoline into an FFV, it adjusts for gasoline. And if you mix the fuels as you would if you topped off a tank, it sets itself to run on the resulting intermediate mixture.

Materials. One of the undesirable properties of methanol is its tendency to be corrosive to many of the metals used in cars, such as steel, aluminum and terneplate. It also attacks many elastomeric materials, such as seals, gaskets, diaphragms. The solution to this problem is not an insurmountable design task - we simply go through the fuel system and wherever we find materials that are incompatible with methanol, we substitute materials that are compatible. This is repeated for the induction system, because air going into an engine does not flow in a steady stream but is full of instantaneous flow reversals. The average flow is in, but at any instant, the flow can be either way. This means that small amounts of fuel & fuel vapors can be found far upstream of where they are injected. So, the air cleaner, for example, must be able to survive when it is subjected to methanol vapors or liquid droplets.

Blowby in the crankcase contains fuel vapors, so anything that comes in contact with oil such as gaskets, oil filters, and positive crankcase ventilation system components must be made of methanol resistant materials. This also includes bearings, piston rings and other internal components. Finally, there is the evaporative control system. The canister, lines, switches and valves in this system must be modified to accommodate methanol. Since the FFV will more than likely be implemented in fleets first, you may be the first to maintain it.

Servicing Flexible Fuel Vehicles

The key areas for servicing an FFV will involve:

- Sensor system;
- Part substitution;
- Water in the fuel;
- Special oil;
- Travel range; and
- Toxicity of methanol.

Sensor System. The most intimidating difference between an FFV and its predecessors, is the fuel composition sensing system. But I am sure that will not be a problem

for you. You already deal with some pretty complex systems today - computer controlled fuel delivery and ignition systems, computerized transmissions and such like. If you have been servicing chrysler products, you are familiar with the DRB - the diagnostic readout box. You can expect that the fuel sensing system will be diagnosed using a similar tool.

Part Substitution. A trickier problem is the potential for installing a similar, but not substitutable, part - examples are gaskets, seals, fuel rails, fuel tubes, fuel pumps, fuel tanks and the like. Even worse, if the inappropriate replacement crates corrosion products, the contaminants may lead to failure of still other components. Fortunately we have some tools to deal with that. We are examining the feasibility of special identification of methanol compatible parts to set them apart from their gasoline-only counterparts.

For your part, this is not an unprecedented situation. You have some directly applicable experience, because you deal daily with parts which are mechanically interchangeable, but you substitute at your peril. You already know that if you put in the wrong spark plugs you may end up with a sputtering engine (if you were lucky and went to cold), or in the worst case, with bits and pieces of engine scattered on the pavement (if you went way too hot). Similarly, wrong injectors may fit but make the engine run rich or lean. A wrong part number electronic controller will plug in, but you might wish you hadn't used it. Put identical appearing valves for a naturally aspirated engine into a turbo and you will be replacing them again very soon. They may look alike, but the material is different. In an FFV there are just some more parts that you have to be sure you are putting in the right thing.

Compatibility of field add-on's is also an important area. Be cautious about miscellaneous accessories and replacement parts that will be in contact with liquid fuel or vapors from the liquid fuel system. Gasoline compatibility does not imply methanol compatibility. The same applies to components which come into contact with engine oil. Due to the fuel in the blowby gases, the oil will be contaminated with the fuel - to a greater or lesser degree depending upon the operating cycle. The oil, with methanol in it, can effect parts it touches. What this means is that after market devices or components that mount in fuel tanks, fuel lines, throttle bodies, air cleaners, positive crankcase ventilation systems, oil filters and so on, may or may not be compatible with methanol - and probably won't be. Methanol compatibility is not a common property of materials that are used in making these components. The materials used have been selected for other desirable properties that made them good choices in the past. For that matter, still good choices for gasoline only vehicles.

Water in the Fuel. Water in the gasoline can be a problem, but its rare, because water will stay on the bottom of a gasoline storage tank unless you pump out the dregs. Likewise, small amounts in you vehicle tank will mechanically disperse in the gasoline and the engine will consume it, more or less willingly, depending upon how much is there. Not so with M85. Methanol is "hygroscopic." The methanol component of M85 will absorb any water with which it comes in contact. This is important since wet methanol won't burn. Tanks containing M85 must be keep them clean and free of water. If you purchase M85, know you suppliers and use only dependable sources.

Special Oil. These vehicles will require a specially formulated oil to be compatible with the methanol and methanol vapors in the blowby gases. Like some of the parts, you would not want to substitute oil formulated for gasoline-only cars. When the FFVs are introduced, the oil companies will be marketing these special oils at their service stations. However, if not, it will be available from car manufacturers.

Travel Range. M85 has only about half the energy content that gasoline has - that means that you only go about half as far on a given amount. So, the range of FFVs, when operated on M85, will only be about half that when operated on gasoline.

Toxicity of Methanol. One item not directly related to the car, which you should take very seriously, is the toxicity of methanol. Do not confuse methanol, also call methyl alcohol, with ethanol, which sometimes goes by the name of ethyl alcohol. Ethanol is the familiar "alcohol" in alcoholic beverages. Methanol is a poison. Small quantities can do serious damage quickly.

You would not think anyone would intentionally drink anything that was 15% gasoline. But what about the person who decides to siphon some fuel from one vehicle to another and gets a mouthful of M85 while sucking the hose full of fuel? We as a manufacturer are concerned enough about this that FFVs will have an anti-siphon device - something to prevent the hose from going down the filler tube and into the tank.

Summary

- FFVs will look and operate just like conventional vehicles but will be more challenging to build and to service.
- The fuel will require some special care in handling, but then so does gasoline, M85 will just add some new concerns.
- Manufacturers - and purchasers - of add-on's will have to consider some new considerations.

If you think FFVs might be in you future, it might be a good idea to start exploring that future possibility with your conversion suppliers, so they can have warning of your new requirements.

To achieve the greatest benefit from an FFV in terms of reducing smog formation and our energy dependence on foreign sources, you must accept the responsibility of maintaining them and keeping them running efficiently.

ALTERNATIVE FUEL SUPPLY

Al Kordel, *AMOCO Oil Corporation*

To understand the supply characteristics of alternative fuels it is important to first understand the supply characteristics of the two predominant traditional motor fuels--gasoline and diesel. I will review the properties of traditional fuels and contrast those properties with those of the leading alternative fuels.

Petroleum Based, Traditional Fuels

Gasoline is a molecular mixture and therefore, it boils between a range of temperatures from about 80 degrees F to 437 degrees F. Its density ranges from about 6 to 6.5 pounds per gallon. Net energy of gasoline is about 18,000 BTUs per pound or about 115,000 BTUs per gallon. Another important characteristic of gasoline is its market demand. Currently there are about 110 billion gallons per year of gasoline consumed in the U.S. The wholesale cost of gasoline is about 70 cents per gallon (May, 1990) before taxes.

Diesel fuel is also a molecular mixture, but has a higher boiling range and is denser than gasoline. Diesel fuel boils from 370 degrees F to 700 degrees F. It's density is about 6.8 to 7.3 pounds per gallon. Net energy of diesel is about the same as gasoline per pound, but on a gallon basis it is higher, 130,000 BTUs per gallon. The U.S. market for diesel fuel is about 20 billion gallons per year. The wholesale cost is about 55 cents per gallon (May, 1990) before taxes.

If gasoline and diesel were introduced today, it is likely there would be considerable safety concerns. Both fuels have several safety concerns. Because gasoline and diesel fuels, however, have been in widespread use for almost 100 years, we have developed safe handling systems or have learned to live with any detrimental safety impacts. Similarly, many handling problems associated with alternative fuels could have been solved if they were given the attention that has been given to gasoline and diesel fuel. Before alternative-fueled vehicles can enter widespread use, however, supply and handling problems will have to be overcome.

An advantage of current petroleum fuels is that production and distribution systems are in place, established, and working. The distribution system supplies high volumes of petroleum products at very low costs. While the cost varies, moving petroleum products from refinery to product terminals via pipelines costs about one to two cents per gallon. Delivery from the terminals to service stations or commercial users in urban areas adds about another two cents. As can be seen, the petroleum industry has established an efficient delivery and distribution system.

Contrasting the existing motor fuel energy system with the pressure to convert to alternative fuels, two questions result: who should accept the costs of establishing new fuels in the market place and, which fuel(s) should be established?

Alternative Fuels

The discussion here will focus on four alternative fuels--methanol, ethanol, natural gas, and liquified petroleum gas. Reformulated gasoline and diesel fuels will also be discussed. Reformulated fuels are significantly different from traditional fuels and can be considered as alternative fuels, even though petroleum is a main component.

Methanol. One reason for the emphasis on methanol is that many consider it to be the leading alternative fuel. It was cited in the original Clean Air Act Amendment proposed by the Bush Administration. Its use is highly touted and it is certainly the fair-haired fuel of California's energy policy where a lot of methanol experimentation is being conducted and more is being proposed.

Structurally, the fuel is an oxygen-containing hydrocarbon. But unlike gasoline and diesel fuel, methanol has one set boiling point because it's structurally consistent