2000 Ford Mustang V6-3.8L VIN 4
Vehicle > Technical Service Bulletins

FUEL ECONOMY - CUSTOMER EXPECTATION VS. VEHICLE USAGE

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99-26-9

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FUEL ECONOMY - CUSTOMER EXPECTATIONS VERSUS VEHICLE USAGE

FORD:
1988-1993 FESTIVA
1990-1994 TEMPO
1990-1997 PROBE, THUNDERBIRD
1990-1999 ESCORT
1990-2000 CROWN VICTORIA, MUSTANG, TAURUS
1994-1997 ASPIRE
1995-2000 CONTOUR
1999-2000 ESCORT ZX2
2000 FOCUS
1990-1996 BRONCO
1990-1997 AEROSTAR, F SUPER DUTY, F-150-350 SERIES
1990-2000 ECONOLINE, RANGER
1991-2000 EXPLORER
1993-2000 VILLAGER
1995-2000 WINDSTAR
1997-2000 EXPEDITION, MOUNTAINEER
1998-2000 F-150, F-250
1999-2000 SUPER DUTY F SERIES

LINCOLN-MERCURY:
1990-1992 MARK VII
1990-2000 CONTINENTAL, TOWN CAR
1993-1998 MARK VIII
2000 LS
1999-2000 NAVIGATOR

MERCURY:
1990-1994 TOPAZ
1990-1997 COUGAR
1990-2000 GRAND MARQUIS, SABLE
1991-1994 CAPRI
1991-1997 TRACER
1995-2000 MYSTIQUE
1999-2000 COUGAR

This TSB article is being republished in its entirety to include vehicles built through the 2000 model year.

ISSUE

Customers may perceive that vehicle fuel economy is lower than it should be, based upon Environmental Protection Agency (EPA) estimates. Fuel economy is most influenced by vehicle usage and duty cycle.

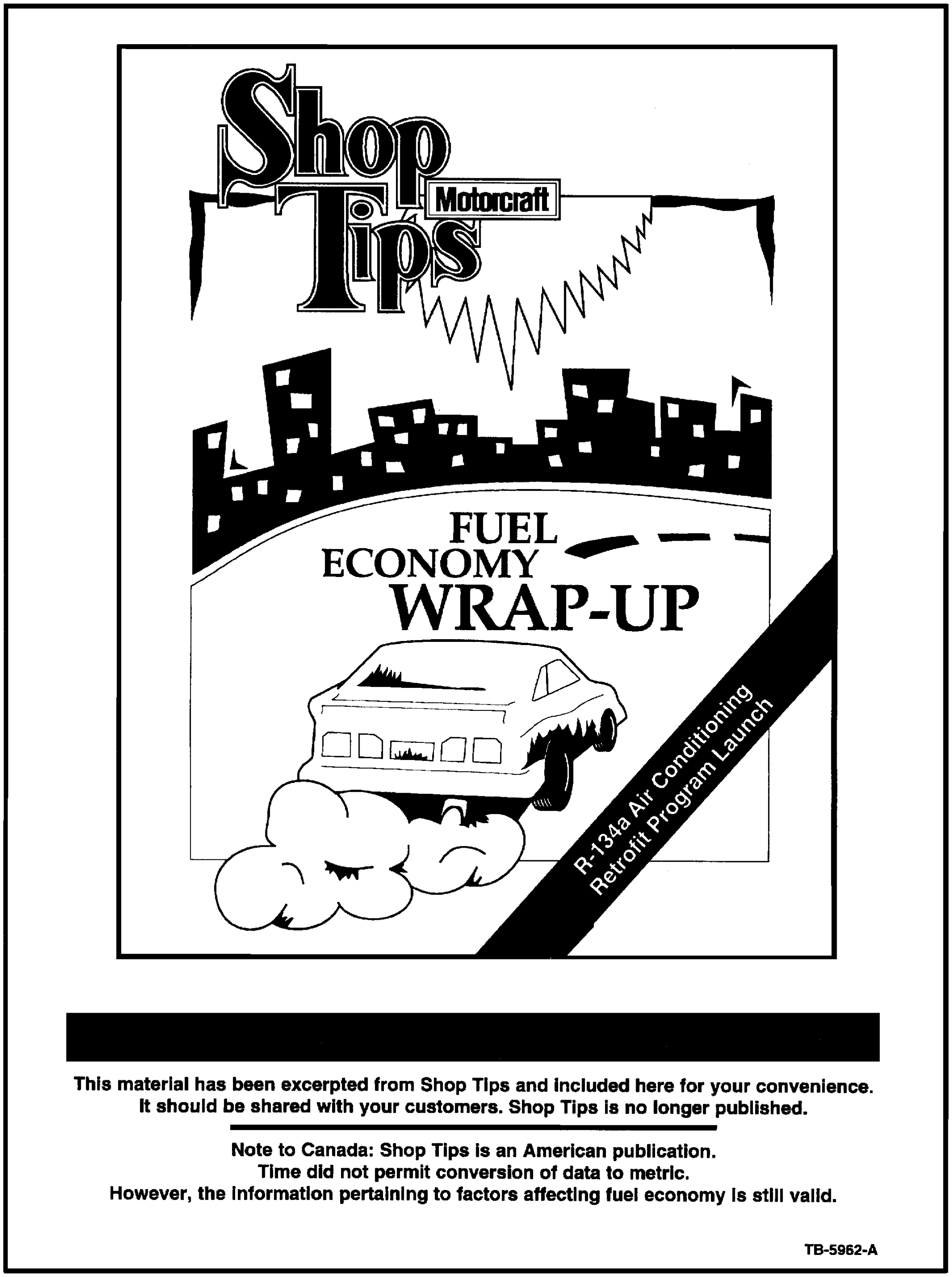
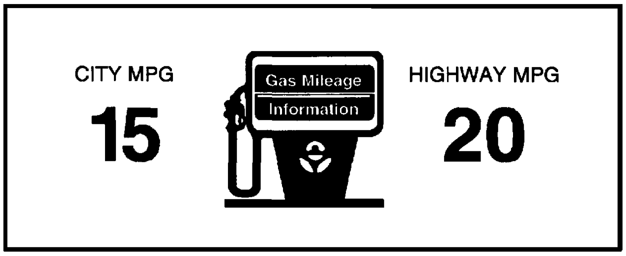


Figure 1

Fuel Economy Wrap-Up



EPA Mileage Estimate On Retail Sticker

HELPING THE CUSTOMER UNDERSTAND FUEL ECONOMY

It is important to distinguish between fuel economy due to the vehicle "usage" versus a malfunction. **"Malfunctions" often are indicated when a significant reduction in fuel economy occurs <u>when operating conditions remain the same.</u>**

In this article, we pull together all the factors that affect fuel economy and see what they really mean for your customer and for you, the technician.

Fuel Economy and the EPA Numbers

The basis for many customer fuel economy concerns are the EPA **City** and **Highway** mpg numbers on the retail sticker (**above**). These numbers are the result of test procedures that were originally developed to measure emissions, not fuel economy.

Very few people will drive in a way that is identical to the EPA tests. You need to point out that the EPA numbers are for comparison between models at the time of purchase and do not reflect the fuel economy an individual will achieve in actual use. If a customer doesn't remember the EPA numbers on the retail sticker, he or she can get that information from the dealership.

For your convenience in explaining these numbers to your customers, we have provided city and highway driving questionnaires on **Figures 5 and 6**. At the top of each questionnaire is an artist's rendition of the driving conditions **simulated** in the EPA testing program and a listing of the test conditions. This information is followed by a list of questions you can ask your customer (or customers can ask themselves). On the basis of the answers, it will become clear that if the customer's fuel economy is less than the EPA ratings, it is due to the driving cycle or the vehicle needing service.

If a customer is driving in a manner very similar to the EPA test conditions and there has been a significant drop in fuel economy, there may be mechanical problems.

Keeping Track of Fuel Economy

If you receive a fuel economy complaint from a customer, you need to determine how they arrived at their numbers. The odometer must be recording properly and they must be filling the tank with the vehicle loaded the same way and on the same level every time. If these conditions aren't met, it's hard to draw conclusions about anything but very big changes in fuel consumption.

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Figure 2

Fuel Economy Wrap-Up

Does It Really Matter?

Figure 4 features a chart that shows fuel costs at various mpg's for a passenger car driven 12,000 miles, a heavy truck driven 12,000 miles and a heavy truck driven 100,000 miles. Two things are clear from these comparisons:

1. The heavier the vehicle, the more the savings from improvements in fuel economy.
2. The lower the vehicle's average mpg, the higher the fuel cost.

For example:

If the price of fuel is $1.00 per gallon and the vehicle is driven 12,000 miles:

- Decreasing from 40 mpg to 37 mpg results in an increased cost of $24.
- Decreasing from 20 mpg to 17 mpg results in an increased cost of $105.

You can help your customer understand his/her cost factors by giving them this formula:

Fuel Cost = $\frac{\text{Miles Driven}}{\text{MPG}}$ x Price of Fuel

In words: Fuel cost *equals* miles driven *divided* by mpg and *multiplied* by the price of fuel.

You may be able to use these comparisons to raise an important question if a customer complains about getting **slightly** lower fuel economy than expected: **Does it really matter all that much?** If the customer is driving an Escort, for example, the answer might very well be, **no**. If the customer is operating a delivery truck, the answer could easily be, **yes**.

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Figure 3

Fuel Economy Wrap-Up

FUEL COST AT $1.00/GAL

FOR A PASSENGER CAR DRIVEN 12,000 MILES

MPG	COST
20	$600
21	$571
22	$545
23	$522
24	$500
25	$480
26	$462
27	$444
28	$429
29	$414
30	$400

FUEL COST AT $1.00/GAL

FOR A HEAVY TRUCK DRIVEN 12,000 MILES

MPG	COST
4	$3,000
5	$2,400
6	$2,000
7	$1,714
8	$1,500
9	$1,333
10	$1,200

FUEL COST AT $1.00/GAL

FOR A HEAVY TRUCK DRIVEN 100,000 MILES

MPG	COST
4	$25,000
5	$20,000
6	$16,667
7	$14,286
8	$12,500
9	$11,111
10	$10,000

Operating Cost And MPG

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Figure 4

EPA City Driving Checklist

EPA CITY TEST CONDITIONS

Cold start
Warm spring day — temperature of 68°F to 86°F
7.5 mile trip
Route mostly level
Trip time 23 minutes
18 stops with approximately 4 minutes of idle time
Moderate acceleration
Average speed 20 mph
Maximum speed of 55.6 mph (for 2 seconds)
Driver only — no additional weight or modifications to the vehicle

CUSTOMER'S OPERATING CONDITIONS (Check conditions that apply)	COMMENTS
☐ Colder driving conditions	Will lower mpg
☐ Hotter driving conditions	Will lower mpg
☐ Longer city driving trips	May improve mpg
☐ Shorter city driving trips	Will lower mpg
☐ Hilly	Will lower mpg
☐ Fewer stops on average	Will improve mpg
☐ More stops on average	Will lower mpg
☐ Abrupt acceleration	Will lower mpg
☐ Constantly working the accelerator	Will lower mpg
☐ Higher average speed	Will lower mpg
☐ Higher maximum speed	Will lower mpg
☐ Heavy loads	Will lower mpg
☐ Accessories that produce drag	Will lower mpg
☐ Frequent trailer tow	Will lower mpg
☐ Lock-up/electronic transmission	Will improve mpg
☐ Other than specified tires	May lower mpg
☐ Tire pressure incorrect	Will lower mpg
☐ Infrequent oil change	May lower mpg
☐ Out of tune	Will lower mpg

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Figure 5


EPA Highway Driving Checklist
EPA HIGHWAY TEST CONDITIONS
Hot start
Warm spring day — temperature of 68 F to 86 F
10 mile trip
Route a mixture of rural and interstate roads — gently rolling
Trip time (?) minutes
No stops — little idle time
Light acceleration
Average speed 48 mph
Maximum speed of 55.6 mph
No additional weight or modifications to the vehicle
CUSTOMER'S OPERATING CONDITIONS
(Check conditions that apply)
COMMENTS
Colder driving conditions — Will lower mpg
Hotter driving conditions — Will lower mpg
Longer trips — May improve mpg
Shorter trips — Will lower mpg
Hilly — Will lower mpg
Fewer stops on average — Will improve mpg
More stops on average — Will lower mpg
Abrupt acceleration — Will lower mpg
Constantly working the accelerator — Will lower mpg
Higher average speed — Will lower mpg
Higher maximum speed — Will lower mpg
Heavy loads — Will lower mpg
Accessories that produce drag — Will lower mpg
Frequent trailer tow — Will lower mpg
Lock-up/electronic transmission — Will improve mpg
Other than specified tires — May lower mpg
Tire pressure incorrect — Will lower mpg
Infrequent oil change — May lower mpg
Out of tune — Will lower mpg
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Figure 6

Fuel Economy Wrap-Up

FACTORS AFFECTING FUEL ECONOMY

Fuel provides the power to move a load against forces that resist that movement. If a route were all downhill, you could coast, using no fuel at all. Real life is rarely that easy. A fuel efficient vehicle is one that has the horsepower to get the job done, while overcoming the resistances that stand in the way. Fuel economy can be looked at in two ways:

1. **Generating the power to move down the road.** This involves three factors:
   a. The **horsepower** the vehicle needs to overcome **resistance.**
   b. The **efficiency** of the engine in generating the needed horsepower.
   c. Horsepower to **accelerate**.
2. **How the vehicle is operated.** How the vehicle is operated is the owner/operator's responsibility. It plays a major role in fuel economy.

Resistance and Horsepower

For a good understanding of the relationship between resistance and horsepower, the following equation for the horsepower (**HP**) needed for a **particular speed** is very helpful.

$$HP = \frac{[V \times .01 \times R \times GVW] + [V^2 \times C \times A]}{375 \times Efficiency}$$

In words, this equation reads: The horsepower needed to achieve a particular speed *equals* the speed (**V**) *times* resistance (**R**) *times* the gross vehicle weight (**GVW**) *plus* the speed squared (**V^2**) *times* coefficient of drag (**C**) *times* frontal area (**A**). These results are *divided* by an **efficiency** factor.

This equation is simpler than it looks. Let's go through it step-by-step:

The two numbers, **.01** and **375**, are included in the formula to make the results come out as horsepower. They aren't directly necessary for an understanding of the basic formula.

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Figure 7

Fuel Economy Wrap-Up

Mechanical Factors

In the first part of the equation **[V x .01 x R x GVW]**:

V is the speed the vehicle is operating at in mph.

R is **rolling resistance + grade resistance**.

Rolling resistance refers to the nature of the road surface. It takes more horsepower to maintain a given speed in soft sand than it does on dry pavement. It is interesting to compare rolling resistance to grade resistance. **The illustration below** shows the effect of different surfaces as if they were hills to climb. For example: Driving on sandy dirt is like climbing a 3.75% grade.

Grade resistance refers to hills. On a hill, it takes more horsepower to maintain a given speed than on level ground.

GVW you are all familiar with. It's the **Gross Vehicle Weight** — the weight of the vehicle and everything in it.

In this equation, **V, R, GVW** and the **.01** are all multiplied together. This gives you the mechanical factors that determine how much horsepower you need to achieve the desired speed. If you **double the speed**, you **double the effect** of these mechanical factors.

ROLLING RESISTANCE

ROAD SURFACE		ROLLING RESISTANCE EQUIVALENT GRADE %
CONCRETE:	EXCELLENT	1
	GOOD	1.5
	POOR	2
ASPHALT:	EXCELLENT	1.25
	GOOD	1.75
	POOR	2.25
HARD PACKED STONE:	EXCELLENT	1.5
	GOOD	2.25
	POOR	3.75
SNOW:	2"	2.5
	4"	3.75
DIRT:	SMOOTH	2.5
	SANDY	3.75
MUD:		3.75-15

Rolling Resistance As Grade

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Figure 8

Fuel Economy Wrap-Up

Aerodynamic Factors

Now we need to add in the aerodynamic resistance factors. They are represented by ***[V^2 x C x A]***.

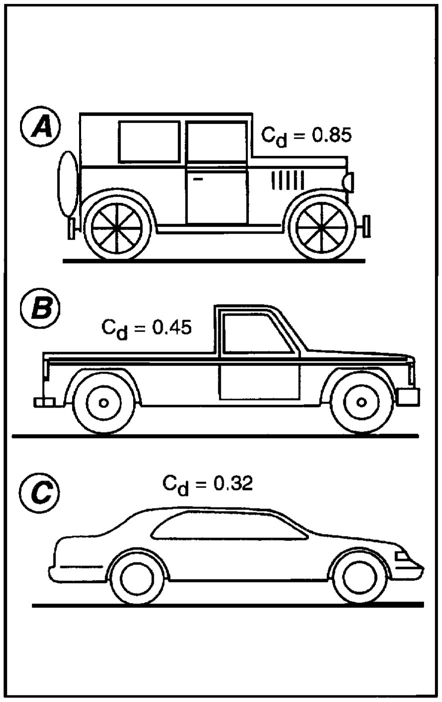
"C" is an ***AIR RESISTANCE FACTOR!*** It is a combination of ***C_d*** and the ***density of the air***. Air density varies somewhat with temperature and pressure. To compute the horsepower needed for speed in our equation, you should use the following value for ***C***:

$C = .002 \times C_d$

Note: Air resistance isn't a significant factor below 25 mph.

C_d is the coefficient of drag. It is a measure of the "sleekness" of the shape of an object and how well a fluid/gas flows over/around it.

A stands for the frontal area. ***The illustration at right*** shows that the frontal areas of the three vehicles are different. You might think that the greater the frontal area, the higher the overall resistance, but this isn't always true. Drag and frontal area have to be considered together. Vehicles A and C have about the same frontal area, but C has a lower drag coefficient, so the overall resistance is lower.



Coefficient Of Drag

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Figure 9

Fuel Economy Wrap-Up

The Illustration In Figure 11 shows an extreme example of frontal area plus drag. The light truck caps being carried on this truck and trailer present a lot of flat fronts to the wind, creating lots of turbulence. Even though the load is light, aerodynamic resistance is very high and fuel economy is very low.

Returning to the formula, V^2 is the desired speed squared. This means **V x V**!

V^2 x C x A tells us something very important. As speed increases, aerodynamic resistance increases even faster! Let's see why that is. Looking at the speed (**V**) alone, let's compare **V** and **V^2** at 55 and 65 mph, and at 65 mph driving into a 15 mph headwind.

55^2 = 3025

65^2 = 4225. This is a **40%** increase in resistance (from speed alone) as a result of only a 10 mph increase in speed (from 55 to 65 mph).

Now let's add in the headwind. 65 mph plus a 15 mph headwind produces a speed of 80 mph **through the air. 80^2** = 6400. With the headwind, the speed component of the aerodynamic resistance has increased an additional **51%** over 65 mph with no headwind. Comparing an 80 mph air speed (65 mph + 15 mph headwind) to 55 mph, results in three times the resistance for a 25 mph increase in air speed.

As you can see, the resistance due to speed alone goes up very rapidly. Added to this is the resistance due to aerodynamic drag and frontal area. To overcome all this resistance, more horsepower is needed, which, in turn, reduces the fuel economy. Anyway you look at it, higher speeds result in lower fuel economy.

Going back to the formula, we see that all these factors we are talking about are divided by **375 x Efficiency.** As we said before, 375 is a number that is included to make the answer come out in horsepower. What is **Efficiency**? In this case, it is a number (often around **.85**) that represents **drivetrain** efficiency. The amount of available horsepower from the engine is reduced somewhat as it passes through the drivetrain. Modem electronically controlled, lock-up automatic transmissions have increased the efficiency of the drivetrain, leaving more of the engine horsepower available to move the load.

This equation can be applied to any operating condition. For example, it can be used to calculate the horsepower needed to move an off-road vehicle at 25 mph through soft sand. If this is an important objective in the design of the vehicle, the equation will indicate how much horsepower must be available from the engine under these conditions.

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Figure 10

Fuel Economy Wrap-Up

Extremely High Resistance

Horsepower and Acceleration

The equation we have just discussed is for a **steady** speed. Additional horsepower must be available for starting up and accelerating during operation. Sudden acceleration requires a lot of fuel and can greatly impact fuel economy.

Air Conditioning

There are some misconceptions about the effect on fuel economy from operating a vehicle's air conditioner. At freeway speeds, it may be more economical to have the windows closed and the A/C running than to operate with the windows open. Open windows at high speeds produce significant drag which may reduce fuel economy more than running the air conditioning system with the windows closed.

At low speeds, such as in city traffic, open windows don't significantly increase drag. Running the A/C under these conditions may affect fuel economy.

HOW THE VEHICLE IS OPERATED

Putting the Owner/Operator in the Picture

Throughout this series we have focused primarily on engineering and design factors that have an impact on fuel economy. Government regulations and fuel availability concerns have driven these efforts. Your customers need to be aware that they also play a major role in achieving good fuel economy. Smooth operation goes a long way to maximizing fuel economy. This means driving at moderate (and appropriate) speeds, accelerating smoothly and avoiding sudden starts and stops.

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Figure 11

Fuel Economy Wrap-Up

Vehicle Speed

It should already be clear from the horsepower formula discussed earlier that high speeds result in poor fuel economy. Rapid acceleration is also a factor. Putting the pedal to the metal uses a lot of fuel. Studies show that operating a vehicle in a smooth, moderate way can save up to 10% on fuel consumption.

Weight and Accessories

It is clear from the horsepower formula that certain accessories and excessive weight will also reduce fuel economy significantly. Accessories include luggage racks and light bars that increase wind resistance. Trailers also contribute a lot of frontal area that results in increased wind resistance.

Heavily loading a vehicle or towing a trailer will sharply reduce fuel economy. Doing both together just compounds the problem. If the customer is carrying or towing heavy loads all the time, he or she needs to understand that they cannot expect good fuel economy. If you are aware that the vehicle is being loaded beyond the designed limits, you should point out that this is a potentially dangerous practice.

Tires

Tires are a significant factor in fuel economy. Properly inflated, O.E.M. tires are part of the vehicle's overall design. Underinflated tires result in significantly lower fuel economy, as well as poor or potentially dangerous handling. Replacement tires that do not meet manufacturer's specifications can also result in lower fuel economy.

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Figure 12

Fuel Economy Wrap-Up

Oil

The right grade of high quality oil is, first of all, a critical part of good vehicle maintenance. The oil should be changed at least as often as manufacturer specifications call for. Certain oil grades contribute to fuel economy. In many vehicles, SAE 5W-30 oil improves fuel economy compared to higher viscosity oils. Follow manufacturer recommendations when it comes to changing oil. To assure the highest quality, select oil that displays the new API certification trademark (**below**).

CORRECTABLE VEHICLE-RELATED FACTORS

If a customer complains of sharply lower fuel economy, question him or her carefully. Make sure that their driving habits and the vehicle's loading have remained the same. Check for any new accessories that might be increasing resistance. If there are no apparent changes in operating conditions, you can look for service related concerns:

- Check that tires are the right type and inflated properly.
- Check the transmission or transaxle for slipping.
- Routine maintenance such as new plugs or timing adjustment may be required.
- Sensors or actuators may be malfunctioning. Look for diagnostic trouble codes.
- Check for brake drag.
- Check the thermostat. It may not be closing, or it may have been replaced with an incorrect thermostat. Either way, if the engine doesn't come up to designed operating temperature, fuel economy will suffer.
- Check that the emission control system is functioning properly.
- In extreme cases, there may be base engine problems such as worn piston rings.
- In very rare situations, the EEC may be functioning in "Limp Home" mode. This default setting allows the vehicle to be driven, but gas mileage will suffer.

THE TOTAL PICTURE

This series on fuel economy has allowed us to look at modern vehicle systems in a special way. Improving fuel economy involves almost every aspect of vehicle design from the shape of the body; to the design of the engine; to where the tires meet the road. Good fuel economy means that all these systems are working together properly. It also means that owner/operators are doing their part. Helping your customers achieve this desirable goal provides a valuable service.

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The New API Certification Trademark

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Figure 13

ACTION

Refer to the Figures of this TSB. Consult this TSB and share with customers to improve their understanding of fuel economy factors.

OTHER APPLICABLE ARTICLES: NONE

SUPERSEDES: 97-6-8

WARRANTY STATUS: INFORMATION ONLY

OASIS CODES: 622000, 690000