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Operating Caterpillar® On-Highway Engines with ACERT™ Technology

This issue of On-Highway News & Views is an update of RMH2004-7 (which was released on April 30, 2004) and again identifies recommendations designed to optimize fuel economy, performance and engine life while operating Caterpillar® engines with ACERT™ technology. The update reflects fuel costs of $2.50 per gallon as opposed to $1.50 per gallon

Almost all the material in this newsletter addresses fuel economy complaints, the understanding of these complaints and some possible solutions. News & Views would like to thank Bob Dussault, Caterpillar product health expert for his very thorough work in creating this impressive treatise.

In addition, Caterpillar has just released a new cue card “Pure Power Driving Tips”, LEXT5351, which is now available in print format.

UNDERSTANDING FUEL ECONOMY COMPLAINTS

Troubleshooting fuel economy complaints requires a basic understanding of some of the many variables that influence a Class 8 tractor fuel economy. Have you ever wondered why, each and every year and in late winter, drivers who operate non-aerodynamic tractors at high speed complain about poor fuel economy? This is because you have just uncovered the three most common and significant factors influencing fuel economy. The ambient temperature, vehicle speed, and tractor-trailer aerodynamics, nearly equal in importance during the winter months, converge to bring the fuel economy penalty to the forefront.

In the following discussion, we will review the most significant factors affecting fuel economy in descending order of importance. The references to fuel mileage penalties percentages are based on a tractor-trailer averaging 6.0 miles per gallon.

DRIVER / OPERATOR

One the most significant fuel economy variable is the driver. It is the driver who controls the vehicle speed, trailer gap setting, acceleration rate, brake usage, idle time, tire inflation pressure, shifting technique and more. It is not uncommon for fleets with identically spec'ed trucks to see as much as 25% (5.0 Vs 6.7 mpg) in fuel consumption penalty between the worst and the best drivers.

INTERSTATE VS CONGESTED ROAD

Avoid operating in congested areas whenever possible. 15% of the miles traveled on congested roads translate into a 7% fuel economy penalty. 25% of the miles traveled on congested roads are equivalent to a 14% fuel economy penalty.

VEHICLE SPEED

Vehicle speed is another very important factor affecting fuel economy. The rule of thumb to remember is that fuel economy will change approximately 0.1 mpg for every 1 mph speed change above 55 mph. In other words, decreasing vehicle speed from 70 mph to 65 mph can improve fuel mileage by approximately 0.5 mile per gallon. The actual fuel mileage improvement depends on the tractor-trailer aerodynamics, ambient temperature, gross weight, and tire type. As speed increases, tractors with poor aerodynamics will experience greater fuel economy loses than vehicles with better aerodynamics.

TRACTOR-TRAILER AERODYNAMICS

The aerodynamic differences between two tractors close-coupled to a Dry Van can amount to 0.55 mpg or a 9% penalty.

The tractor-trailer gap for a high cube trailer (Dry Van, Reefer) is another factor affecting aerodynamics. A 6' gap can represent a 7.5% penalty or 0.45 mpg. Testing by a major OEM has shown that for every 10 inches of trailer gap, the fuel mileage changes 1%.

The tractor-trailer combination can represent up to 1.8 mpg or a 30% difference in fuel mileage penalty. This is based on a comparison between an aerodynamic tractor-trailer (Dry Van) with an 18" gap and a Car Hauler, both with 80,000 lbs GCW.

As you can see, the tractor-trailer aerodynamic package is another very large contributor to a vehicle fuel mileage performance. It is ironic that a tractor with poor aerodynamics can generate a larger trade-in residual value. A business decision should be made to weigh the additional fuel cost against the tractor higher trade-in value.

CLIMATE / AMBIENT CONDITIONS

The average Mid-West winter months daily temperature of 25°F is responsible for a 13% fuel mileage penalty compared to summer time conditions of 70°F or higher. Cold air is denser and increases the aerodynamic drag on the tractor-trailer.

High winds, terrain, and snow-covered roads can also change fuel economy by an additional 13% compared to a calm day and well-maintained roads.

FUEL

Winter fuel measuring 38 API gravity (lower energy / lower BTU content) is responsible for another 2.5% fuel mileage penalty.

The total AVERAGE Mid-West WINTER TIME (25°F) penalty on fuel economy amounts to 15.5% (13% temperature + 2.5% winter fuel) or approximately 0.9 mpg. At 0°F, the fuel penalty approaches 1.1 mpg.

Winter fuel with higher API gravity will generate a higher fuel mileage penalty. In the southern region of Canada, 41 API fuel translates into a 5% fuel mileage penalty (0.3 mpg). Further north, kerosene with 48 API gravity results in a 15% fuel mileage penalty (0.9 mpg).

IDLE TIME

The fuel consumed by an idling diesel engine is not as significant as many people believe. In terms of impact on fuel mileage, it ranks near the bottom of the list of factors affecting fuel economy. This is not to say that idle time should be ignored. The cumulative effect of small improvements can be very significant. Idling, unless it is necessary to maintain a comfortable driver environment or provide PTO (power take-off) power, is unnecessary.

A perspective on idling can be gained with the following example: A tractor-trailer engine consumes 11 gallons of fuel per hour while driving and 1.0 gallon per hour while idling to keep the driver comfortable. The following chart compares the idle fuel consumption between 50%, 33 1/3%, and 20% idle time.

50 % Idle Time			
Driving Fuel	**Idling Fuel**	**Idling Fuel % of Total**	**Idling Fuel MPG penalty**
10 hrs X 11 gal / hr = 110 gal	10 hrs X 1.0 gal / hr = 10.0 gal	8.3 %	**0.50 mpg**
33 1/3 % Idle Time			
10 hrs X 11 gal / hr = 110 gal	5 hrs X 1.0 gal / hr = 5 gal	4.3 %	**0.26 mpg**
20 % Idle Time			
10 hrs X 11 gal / hr = 110 gal	2.5 hrs X 1.0 gal / hr = 2.5 gal	2.2 %	**0.13 mpg**

The above examples show that a very significant 50% reduction in idle time (50% down to 33 1/3% / 10 hours down to 5 hours) contributes to improving fuel economy by 0.24 mpg. A second attempt to again reduce idle time by 50% (33 1/3% down to 20% / 5 hours down to 2.5 hours) improves fuel mileage by 0.13 mpg. With much less management time commitment and training effort,

reducing vehicle speed by 2 mph (3% change) can improve fuel economy by nearly 0.2 mpg.

TIRES

Tires are available with different types of tread design suitable for various applications.

Deep Lug, improve traction at the expense of higher rolling resistance. Shallow Lug, reduce the tread depth to decrease the rolling resistance. Rib, sacrifice traction but offer lower rolling resistance and better fuel economy.

In addition, there are tall tires (11R24.5), low profile tires (285/75R24.5), and wide base (singles) tires (445/50R22.5). The tall tires exhibit a little more rolling resistance because of the increased flex of the taller sidewall. Low profile tires have a weight advantage and less rolling resistance. The wide base (singles) tires can provide up to an 800-pound advantage over duals on the tractor alone. A similar weight saving can be realized on the trailer. The wide base (singles) tires offer the least rolling resistance. In the real world, do not expect more than a 3 - 4% improvement in fuel economy with wide base (singles) installed on both the tractor and the trailer.

Some facts to consider:

- All tires are at their least fuel-efficient point when new. As the new tire wears, the rolling resistance decreases and fuel economy improves.

- The majority of the fuel economy advantage is obtained when the tread is 50% worn.

- Regular radial tires and fuel economy labeled tires provide nearly the same fuel economy as they approach wear out.

- Above 45 mph, air resistance / aerodynamics is a more important consideration than tire rolling resistance.

- Fuel-efficient tires loose half of their fuel efficiency benefit when vehicle speed increases from 60 to 75 mph.

- Retreads are nearly equal to new tires in rolling resistance.

LOAD / GCW

A 10,000-pound reduction in payload will increase fuel savings by about 4.4%. A reduction in gross weight from 80,000 lbs to 60,000 lbs will generate an 8.8% improvement in fuel savings. Pulling an empty trailer will only increase fuel savings by 21%.

GEARING

The gearing of a tractor (drive axle ratio) is based on several factors including the drive tires revolutions per mile, transmission top gear ratio, engine torque rating, GCW (gross combination weight), gradeability requirement, tractor-trailer aerodynamics, application, and vehicle speed. Gearing is a compromise between truck performance and fuel economy. Fuel cost is a substantial part of the total owning and operating cost (second in importance after driver's pay) and therefore optimum gearing leans toward the fuel economy side of the equation.

Some operators of trucks geared for best fuel economy can compensate for any reduced performance by down shifting prematurely and more often to keep the engine rpm in the peak horsepower range. Driving this way defeats the purpose of "Gear Fast – Run Slow" and can lead to poor fuel economy complaints.

TRANSMISSION

A Direct Drive transmission, one with a top gear ratio of 1.00:1, can be 2% more fuel efficient than an Overdrive transmission.

OTHER FACTORS

There are several other variables that can affect fuel economy of all on-highway trucks. Road congestion, tire air pressure too low, axle and front end alignment, vertical-rib and/or open-top trailers, etc… Even small things like adding a bug deflector or driving with the side window(s) down can have an adverse affect on fuel economy.

Most fuel economy complaints can be explained with a basic understanding of some of the variables that affect fuel efficiency. These complaints typically occur during the winter months when fuel economy drops significantly. Customers purchasing new trucks during the winter months will experience this phenomenon. Not only do they suffer the fuel economy loses of the winter months but also have new tires and a minimum 30,000-mile "break-in" period to contend with. All new vehicle components (engine, transmission, drive axle, drive line U-joints, wheel bearings) require a "wear-in" period.

CUSTOMER FACTORS

One of the first steps in investigating a fuel economy complaint is to inspect the tractor-trailer and interview the driver. Consider the engine horsepower and torque, cruise speed, look at the aerodynamics of the tractor-trailer, the type of trailer and load pulled, the type of tires on the drive axles and check the gearing of the truck. Compare the tractor gearing with Caterpillar's gearing recommendations. Ask the customer about their driving techniques.

Find out what the customer thinks the fuel mileage should be and why they think that. Many times they are comparing their truck to another truck with different aerodynamics and gearing. The engine might be the same but the chassis' could be completely different. The customer may also be referring to the worst conditions encountered during the winter months. Occasionally, they will mention that the selling dealer told them what fuel mileage they should expect out of the truck. "Estimating" the fuel mileage of any given truck can be difficult and time consuming. The Driver influence alone can be a significant factor in the fuel economy results.

The next step is to download the engine ECM information and proceed with the ENGINE PERFORMANCE ESTIMATOR software.

Pay attention to the cruise speed, the months of the year the tractor-trailer fuel mileage represents, the engine rpm at cruise speed and the percent idle time. Compare the ECM fuel mileage with the actual tank mileage obtained from the customer records. The customer records MUST be available.

Fuel Economy Comparison between Tractor-Trailers

When comparing Fuel Economy between tractor-trailers, AVOID making comparisons between apples and oranges. This sounds easy and obvious but it is done all the time. Below, you will find some recommendations to avoid common mistakes.

Engine Displacement

When comparing the fuel mileage of engines with different displacement such as a 12L and a 15L engine, the lower displacement engine usually has an unfair

advantage. For a similar horsepower rating, the engine with the lower displacement has the advantage with higher cylinder pressure (BMEP) and lower pumping losses that translate into slightly better fuel economy. When a customer talks about fuel economy, he is interested in operating costs. Fuel economy is only part of the life-cycle cost. The tractor residual value at trade-in time is also an important part of the consideration when spec'ing a 12L or a 15L engine. How much can I sacrifice in fuel economy in exchange for higher resale value?

Engine Emission Certification Level

Compare engines of the same model year and/or of the same emissions certification level.

ECM Data Accuracy

When downloading the ECM data, make sure the information obtained represents the same calendar period of operation for all tractors. The **ambient temperature** is one of the **most significant factors** affecting fuel economy. The winter-blend fuel with a higher API gravity (lower BTU content) provides an additional fuel mileage penalty.

Distance Traveled

Is the tractor Odometer Reading accurate? How does it compare to the Hub-O-meter reading or the ECM Mileage?

Is the PPM (Pulses per Mile – ECM programmable parameter) number correct? Details are found on the next page.

Fuel Consumption

Is the fuel consumption measured at a calibrated fuel pump or with the ECM? How do they compare?

Some engine manufacturers make sure that the ECM calculated fuel economy is better than the actual fuel mileage recorded at the pump. Make sure you compare the ECM Data with the actual fuel purchased by the customer. The ECM may not be programmed or calibrated properly and may not record distance and fuel consumption accurately.

Programming PPM
(Pulses per Mile)

The PPM number programmed in the ECM may be incorrect. Make sure that the Drive Tires Revolutions per Mile is correct. Verify both, the tire size and **specific tire model** to obtain the correct drive tires revolutions per mile.

A) HIGH PPM (High Drive Axle Tire Revolutions per Mile):

- ECM displays Lower MPG number
- MPG calculations based on actual fuel purchases also show Lower MPG number due to the speedometer error (actual distance traveled is Longer)
- Speedometer reads Low
- Actual truck speed is Higher
- PENALTY $\Rightarrow$ Lower MPG due to Higher vehicle speed

B) LOW PPM (Low Drive Axle Tire Revolutions per Mile):

- ECM displays Higher MPG number
- MPG calculations based on actual fuel purchases also shows Higher MPG number due to the speedometer error (actual distance traveled is Shorter)
- Speedometer reads High
- Actual truck speed is Lower
- BONUS $\Rightarrow$ Better MPG due to Lower vehicle speed

PPM = Drive Tires Revolutions / Mile X Drive Axle Ratio X * Number of Teeth
(Chopper Wheel)

* The number of teeth on the transmission output shaft chopper wheel is normally **16**, sometimes 11, and can be any number of teeth.

Road Test – HOW TO COMPARE TWO OR MORE TRACTOR-TRAILERS

References SAE Type 2, J1321 / Type 3, J1526 / Type 4, ATA procedure

Same Fuel Island

Fill up at the same fuel pump, park in the same spot (chalk mark), before and after the trip. The fuel temperature must be the same when measuring fuel consumption in gallons. A smaller fuel tank may contain hotter fuel, causing the engine to consume a larger volume of fuel to obtain the same BTU content.

200-Mile Round Trip

Plan at least a 200-mile round trip to maintain a reasonable level of data accuracy.

Spec'ed the Same Way

The tractors and trailers should be spec'ed identically except for the component (engine) to be evaluated for fuel economy performance.

- The engine……...same model year and emissions certification level
- Tractor……..same configuration, aerodynamics, fifth-wheel height
- Transmission……..Overdrive or Direct Drive, NOT both
- Axle ratio……..same or based on the manufacturer gearing recommendations
- Tires……..……same model, same tire wear and inflation pressure
- Trailer and trailer gap….same height and configuration
- GCW…….within 1000 lbs
- Other variables……same

New Tractors and Trailers (30,000 Miles)

The comparison should take place after the break-in period -- 30,000 miles minimum.

1/4-Mile Apart

Maintain visual contact during the road test, 1/4 mile apart. This minimizes differences between important variables affecting fuel economy (ambient temperature, wind, vehicle speed, road congestion, and idle time).

Mimic Each Other

Mimic each other. Drive at the same legal and safe speed. All should idle the same amount. Use the transmission top gear and cruise control whenever possible.

Switch Trailer

Switch trailer at the halfway point. The driver stays with the tractor.

COMPLAINT: Low Power / Low Power and Poor Fuel Economy / Poor Fuel Economy

To improve your fuel mileage, follow these recommendations

Slow Down -- Do not exceed 60 mph. This can be implemented immediately and does not require up front capital investment. It is likely to be your largest cost saving item.

Spec Smart -- For your next purchase, consider a Tractor-Trailer with good aerodynamic characteristics and low rolling resistance tires. "Gear Fast / Run Slow" is also recommended for most 80,000 pounds GCW (Gross Combination Weight) applications.

Don't Idle -- Do not run the engine at idle anymore than absolutely necessary.

Driver Training -- You will learn proper operating habits that will save money on fuel, tires, brakes, and tractor-trailer maintenance. A safe driver is also rewarded with a more enjoyable driving experience.

SUMMARY OF SIGNIFICANT FACTORS INFLUENCING TANK MILEAGE

(Continue to next page)

SUMMARY OF SIGNIFICANT FACTORS INFLUENCING TANK MILEAGE

	(% Penalty)
DRIVERS:	
Worst to Best drivers within a Fleet -- (5.0 - 6.7 mpg)	25%
ROUTE:	
Interstate Vs Congested Road -- (up to 1.2 mpg)	20%
VEHICLE SPEED:	
60 Vs 70 MPH -- (0.8 mpg or more / Aero dependent)	13%
AERODYNAMICS:	
Worst to Best class 8 tractors at 65 MPH -- (0.55 mpg)	9%
Dry Van / Refer Vs Livestock trailer at 65 MPH -- (0.9 mpg)	15%
CLIMATE:	
Summer (70°F or higher) Vs Winter (25°F) -- (0.75 mpg)	13%
Wind / Terrain (On any given trip) -- (0.75 mpg)	13%
FUEL:	
#2D (API 35) Vs Winter Blend (API 38) -- (0.15 mpg)	2.5%
#2D (API 35) Vs Kerosene (API 48) -- (0.9 mpg)	15%
IDLE TIME:	
10% Vs 40% idle time -- (0.25 mpg)	4%
TIRES:	
Radial Vs Wide Base (Singles) -- (0.25 mpg for tractor and trailer)	4%

NOTE: 10% = $5,000. / Year / Tractor
(Assuming 120,000 miles / 6.0 mpg / $2.50 per gallon)

REMINDER: ACERT ALERT

Don't forget to enroll at
www.acertalert.com

Submit all your newsworthy items to:

Caterpillar Inc. On-Highway Marketing
Attention: Ray Hartwell
P.O. Box 610, MOS 25
Mossville, IL 61552

Email: Hartwell_Raymond_M@cat.com

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