EVERY CUSTOMER.

CUMMINS FUEL ECONOMY GUIDE

Cummins

Secrets of Better Fuel Economy

Contents

Introduction: Understanding Fuel Economy

The importance of fuel economy to the successful operation of a transport company cannot be understated. Fuel is one of the largest variable costs in a transport venture, and, while no operation can control the cost of fuel, it has at least some control over the amount or rate of consumption.

Rock-Solid Rules

- Every 2% reduction in aerodynamic drag results in approximately 1% improvement in fuel economy.
- Above 90 km/h, each 2 km/h increase in vehicle speed decreases fuel economy by nearly 2%.
- Worn tyres provide up to 7% better fuel economy than new tyres.
- Used lug drive tyres can get up to 0.2 km/litre (0.5 mpg) better than new lug tyres.
- Ribbed tyres on the drive axles provide 2% to 4% better fuel economy than lugged tyres.
- Every 70 kPa (10 psi) that a tyre is underinflated reduces fuel economy by 1%.
- The break-in period for tyres is up to 50,000 km.
- Tyres make the biggest difference in fuel economy below 80 km/h; aerodynamics is the most important factor above 80 km/h.
- The most efficient drivers get about 20% better fuel economy than the least efficient drivers.
- Idle time is costly. Every hour of idle time in a long-haul operation can decrease fuel efficiency by 1%.

Vehicle Power Requirements

In the simplest of terms, you burn fuel to make horsepower, and you use horsepower to overcome all of the forces that are trying to retard or hold back the truck. So, a truck that rolls down the road with minimum drag will use less horsepower and consume less fuel.

The power required to maintain a given road speed depends on the sum of the following forces:

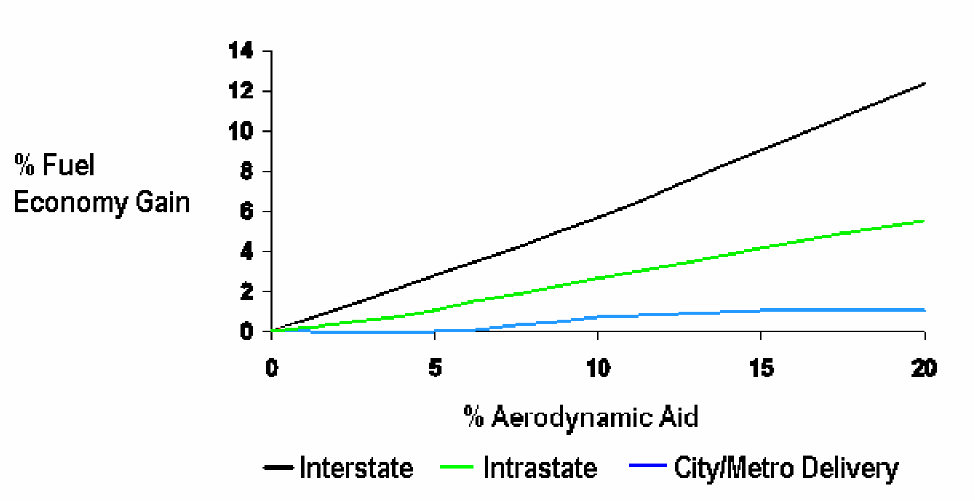
- Aerodynamic Drag
- Grade Resistance
- Tyre Rolling Resistance
- Engine Accessories (eg. cooling fan)
- Drivetrain losses

This section reviews these items in detail to demonstrate the impact of each on fuel savings.

Aerodynamic Drag

Aerodynamic drag is the result of forces (pressure imbalances) acting on a vehicle as it passes through the air. The magnitude of the forces acting on a vehicle depends on speed, frontal area and external shape. Aerodynamic drag is the most significant contributor to vehicle power requirements above a speed of 80 km/h.

As the following graph shows, aerodynamic aids can have a major impact on vehicle fuel economy on an interstate duty cycle and very little impact on a city-metro duty cycle.

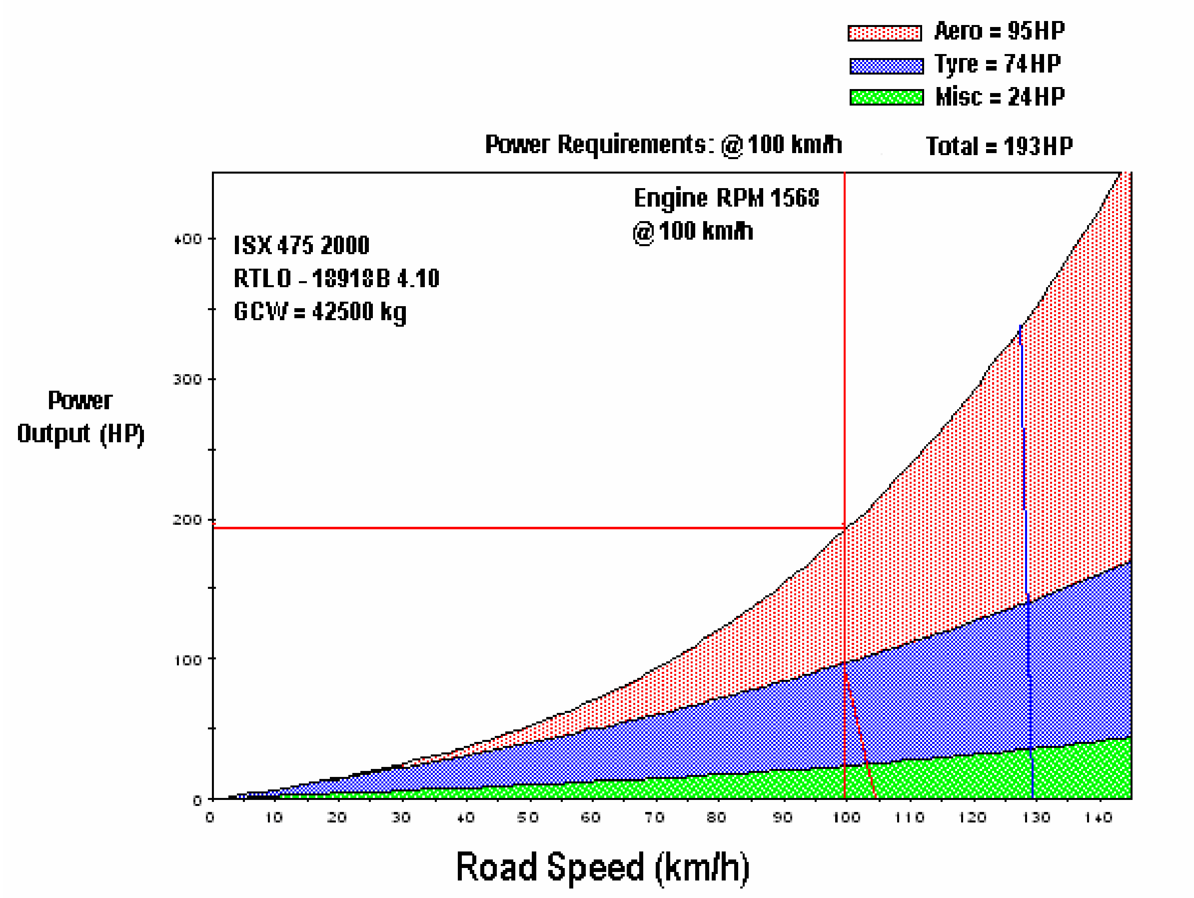


No Aerodynamic Treatment (0%)

In this case, 193 hp is needed to overcome all of the forces acting on the truck and to keep it rolling at 100 km/h on level road. Aerodynamic forces (wind resistance) account for 95 hp (over half) of the power demand.

"Balanced" Level Road Power Requirements

ISX 475, Single Curtainsider, 4.10:1 axle, 11R22.5 tyres, No Aero

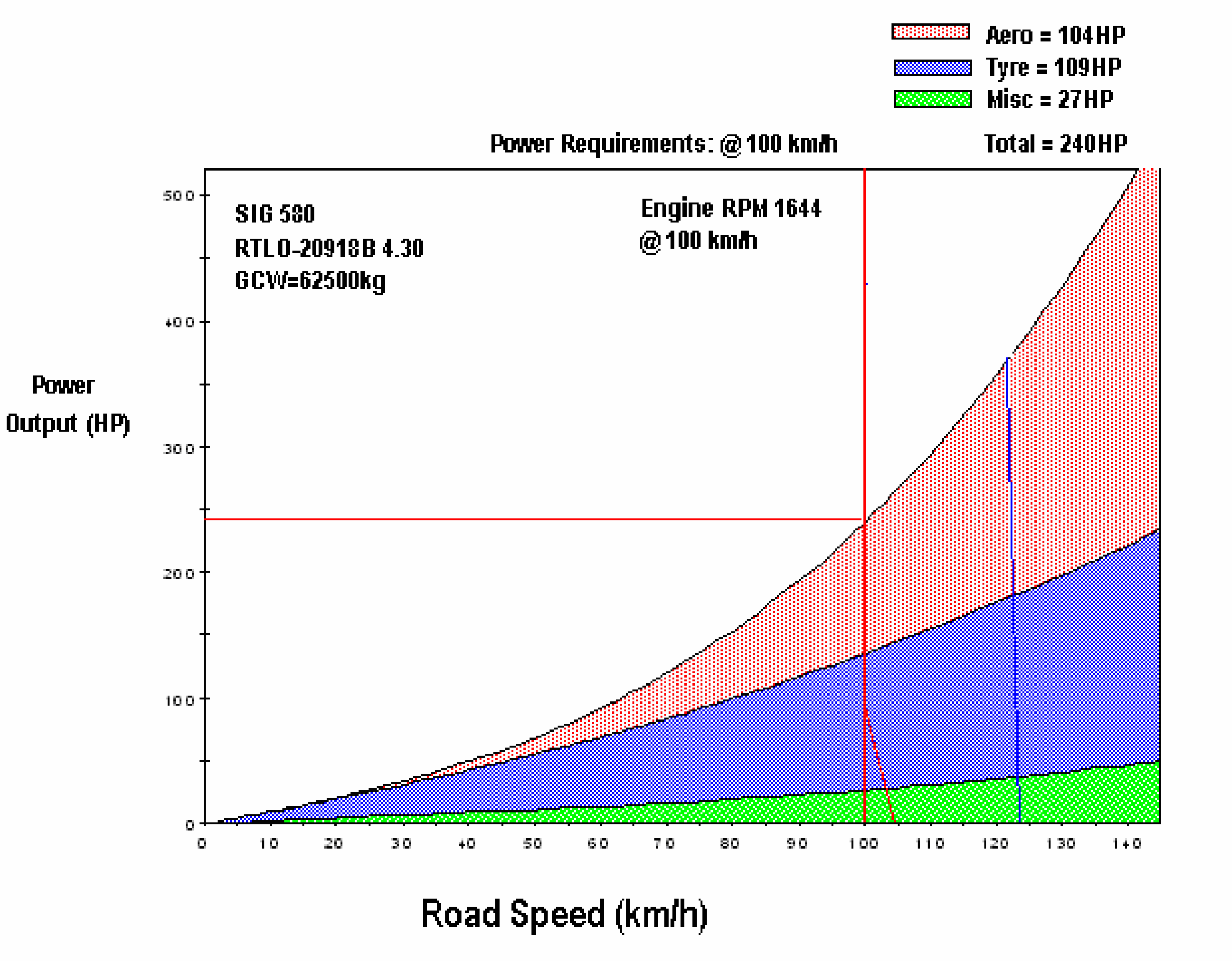


Rock-Solid Rule
Tyres make biggest difference in fuel economy below 80 km/h. Aerodynamics is the most important factor over 80 km/h for Single Trailers

No Aerodynamic Treatment (0%)

Signature 580, Double Curtainside, 4.30:1, 62,500 kg, No Aero Treatment (0%)

With loaded B Doubles 240HP is required to overcome forces acting on the truck rolling at 100 km/h on level road. Tyres and rolling resistance are the biggest effect.



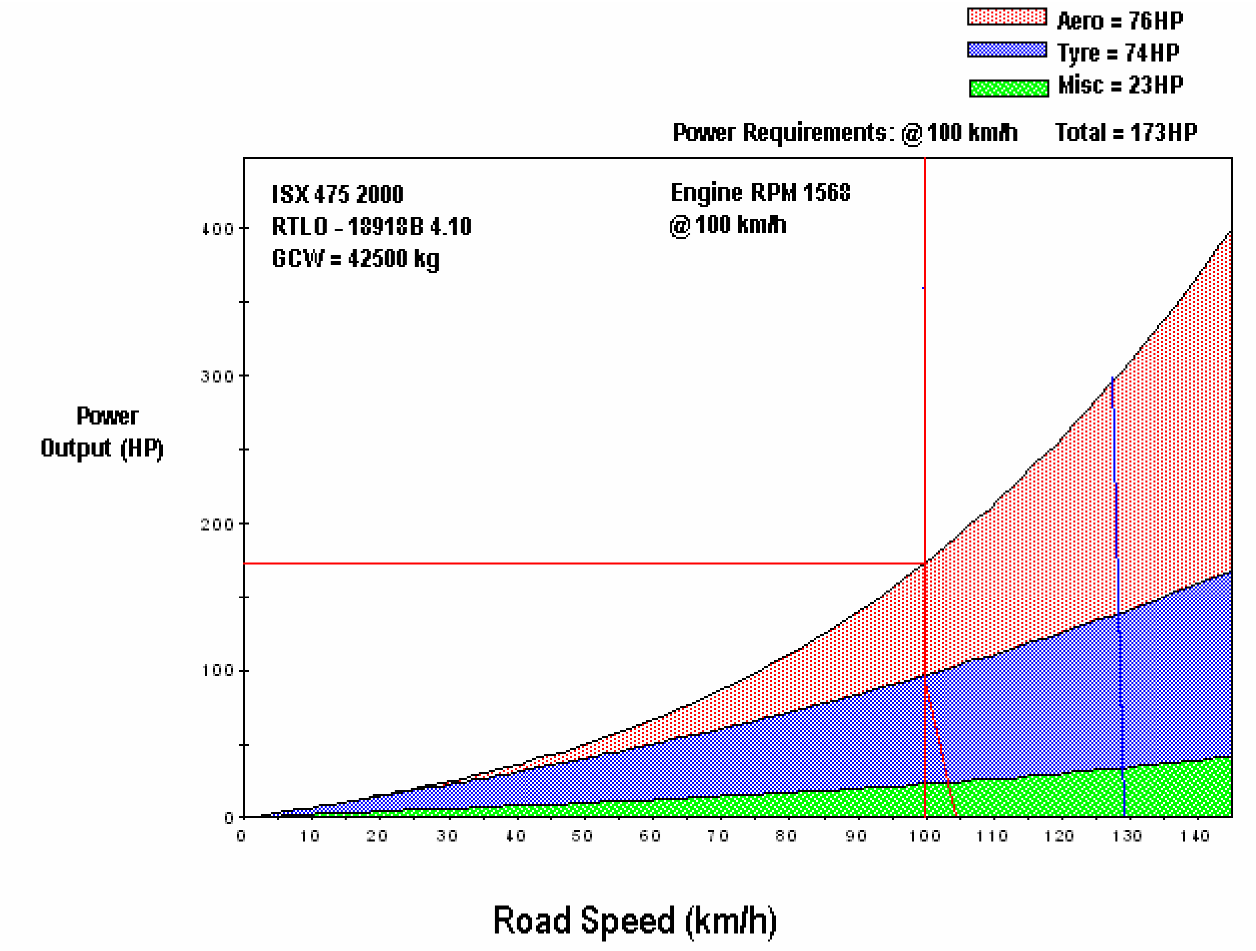
B Double Curtainside, 4.30:1 axle ratio, 11R22.5, No AERO AIDS

Full Aerodynamic Treatment (20%)

Aerodynamic treatments can reduce the horsepower required to move the truck by 20 horsepower. Notice in this example that a vehicle equipped to reduce air resistance also reduces power required from 95 hp to 76 hp, a reduction of 20%.

"Balanced" Level Road Power Requirements

Single Curtainside Trailer 4.10:1 axle, 11R22.5 tyres, Full Aero



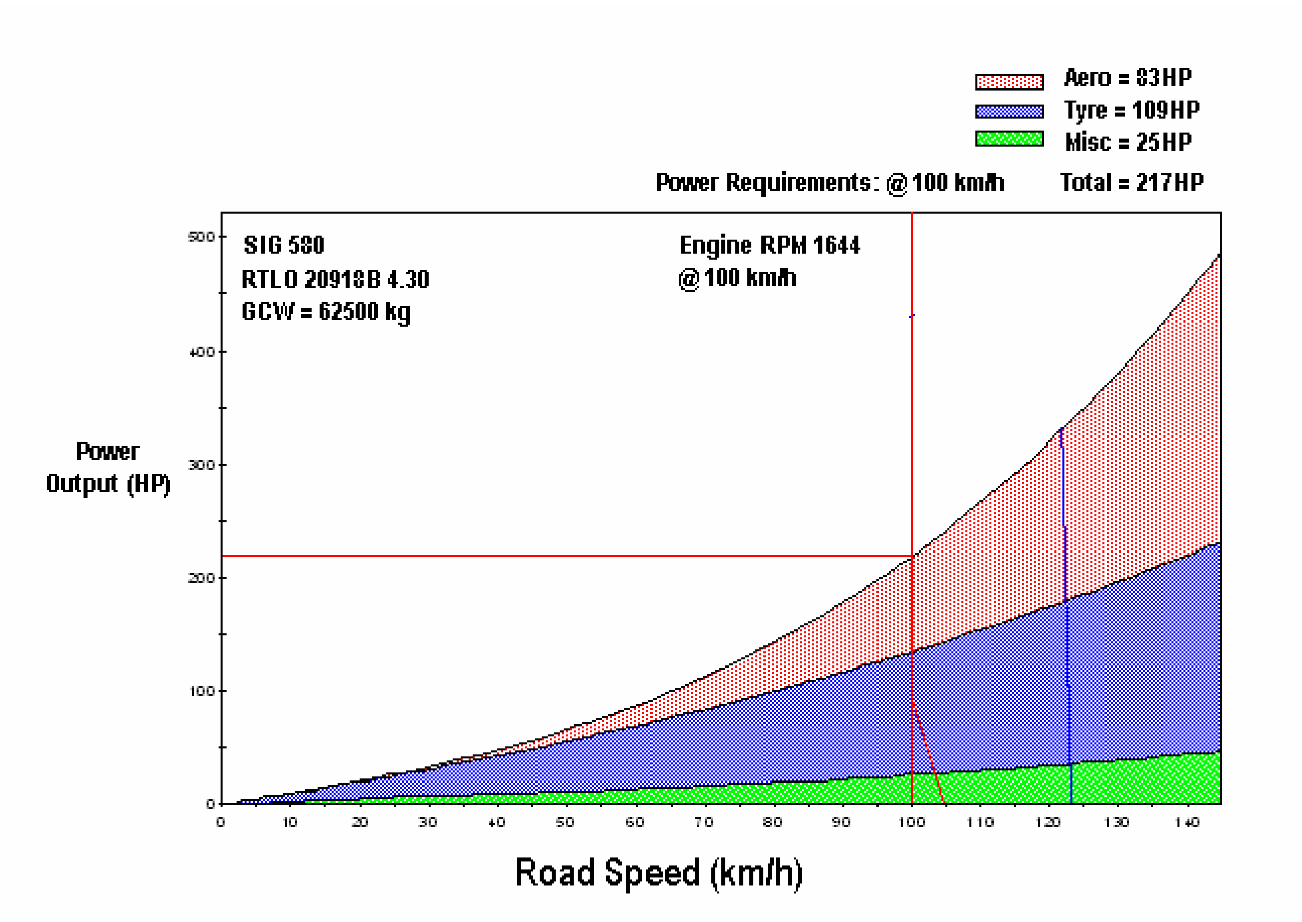
Aerodynamic treatments are more effective at higher speeds and the power required to overcome things like tyre rolling resistance are not affected by the aerodynamic aids.

Full Aerodynamic Treatment (20%)

"Balanced" Level Road Power Requirements

B Double Melb-Syd-Melb Curtainside, 4.30 axle ratio Full Aero

In this example the vehicle with aeros reduces power required from 104hp to 83hp, a reduction of 20%.



The following graph shows how the impact of aerodynamic treatments depends on speed. For trucks in pickup and delivery operations in urban areas, the cost and maintenance of aerodynamic treatments may outweigh the benefits. However, for a highway prime mover/trailer combination, the fuel savings from aerodynamic treatments may quickly offset the higher initial purchase price of the equipment.

Aerodynamic Power Requirements

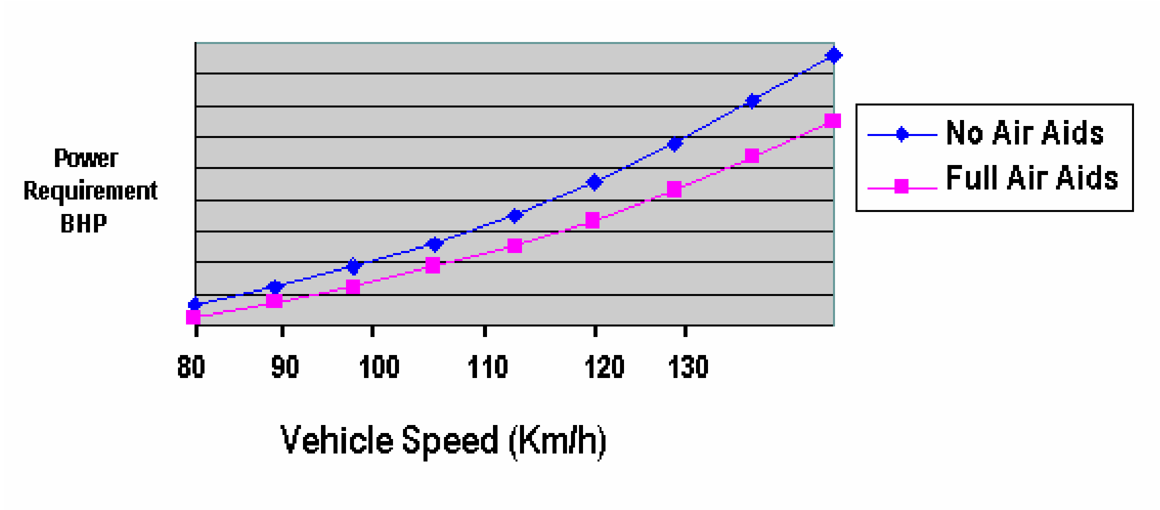


Table 1: Comparison of Treatments

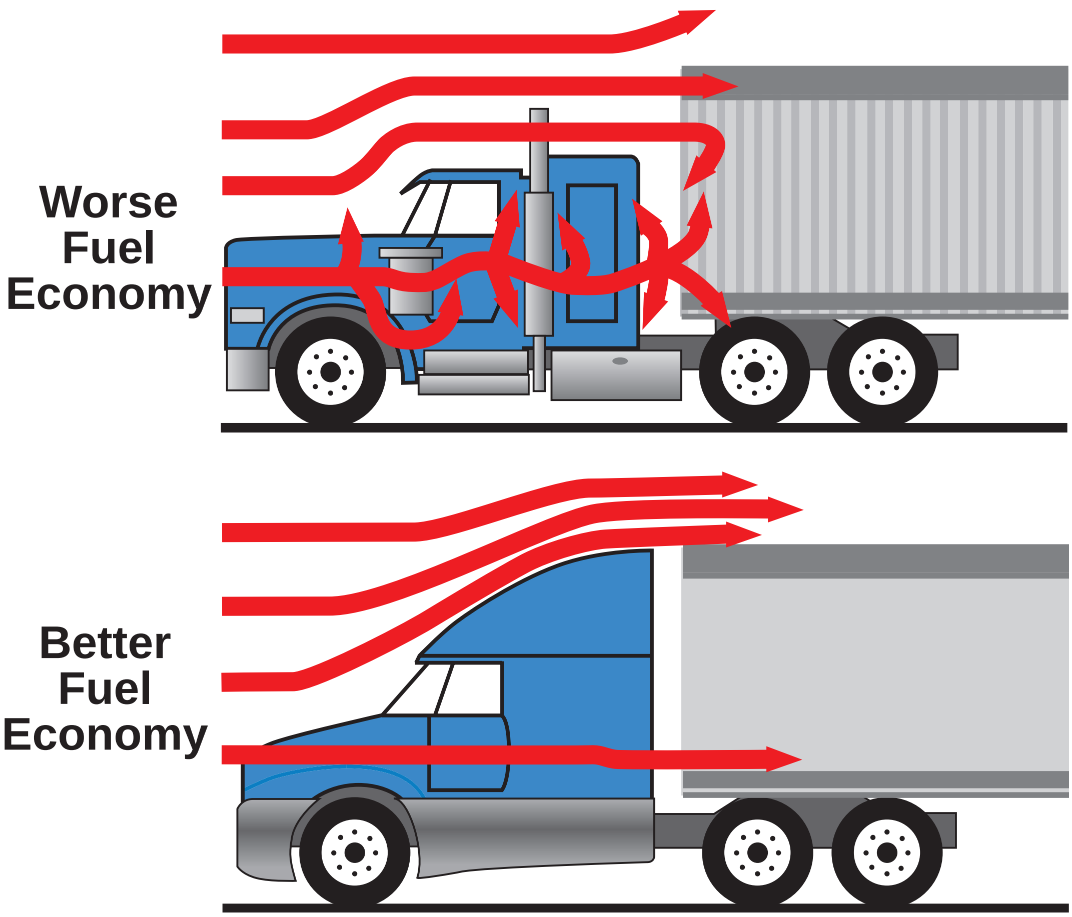
	Aerodynamic Power Requirement (hp) @ 100km/h
No Aerodynamic Treatment	95
Full Aerodynamic Treatment	76
	19 (hp difference)
Economy advantage Assuming an avg. of 250 hp requirement	~ 8 % better economy

(19/250 = 7.6%)

Cab Aerodynamic Considerations

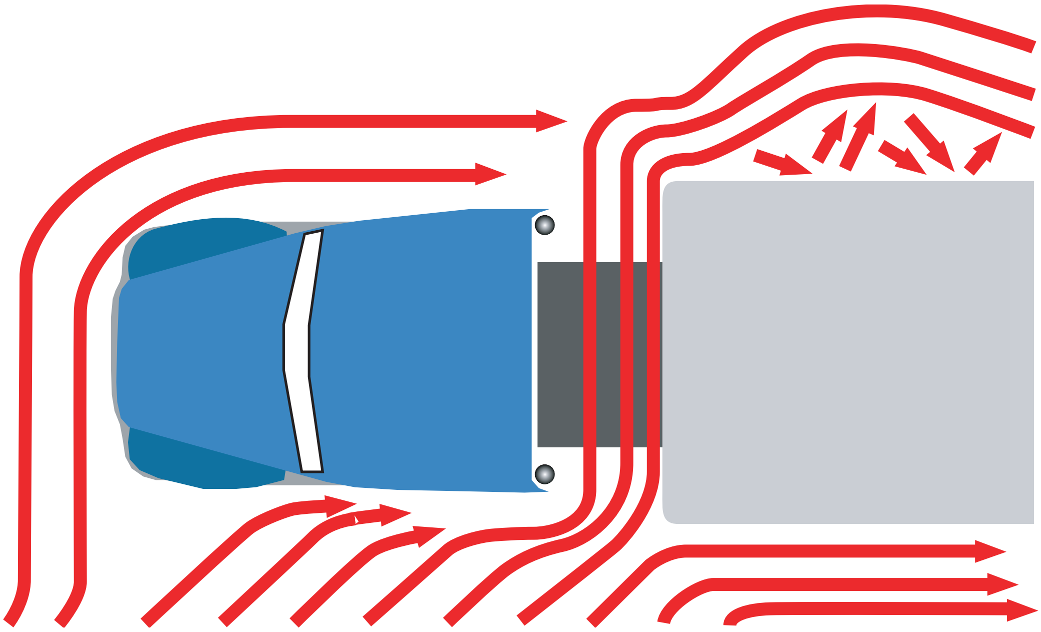
Not every truck has to be fitted with all of the aerodynamic features available. The list here shows some of the items and their effect on aerodynamic efficiency. Trailer type and loads hauled in addition to the vehicle speed will determine the effectiveness of a particular item.

- Full Roof Deflector 5-10%
- Fairing
- Sloped Hood 2%
- Round Corners
- Aero Bumper 2%
- Air Dam
- Flush Headlights 0.5%
- Slanted Windshield
- Curved Windshield
- Side Extenders 1-7%
- Skirts
- Under Hood Air Cleaner(s)
- Concealed Exhaust System
- Recessed Door Hinges
- Grab Handles



Truck-Trailer Air Gap

To minimise drag resulting from crosswinds and turbulent air, truck-trailer gaps should be minimised or aeroskirts should be used to smooth the airflow. Beyond approximately 750 mm, every 250 mm increase in truck-trailer air gap increases aerodynamic drag by approximately 2%. If axle weights allow, slide the fifth wheel forward to minimise the gap and reduce wind resistance.



> <u>Rock-Solid Rule</u>
> Every 2% reduction in aerodynamic drag results in approximately 1% improvement in fuel economy.

Trailer Body Aerodynamics

Drag characteristics of trailer configurations and body styles can vary, and therefore will impact fuel economy.

A smooth-side van trailer with rounded corners at the front offers the least resistance.

Table 2: Common Trailer Bodies Exhibiting Higher Drag

Trailer Types	*% Increase in Aerodynamic Drag*
Square corner/vertical rib (eg. Containers/Curtainside)	5-10 (2.5% to 5% less economy)
Drop decks/Flat top with irregular shaped loads	10-30 (5% to 15% less economy)
Stock crates	10-30
Car carriers	10-30

Extra trailers adds extra drag.

Engine Accessory/Drivetrain Losses

Although largely fixed, engine accessory and drivetrain losses can significantly contribute to total vehicle power requirements.

Engine accessories consist of:

- Cooling fan
- Freon compressor
- Air compressor
- Alternator
- Power steering

Drivetrain consists of:

- Oil Windage/Churning
- Frictional losses

Gearing

The rpm level where the engine cruises can provide critical fine-tuning of fuel economy. To do this, you can spec the gearing so that the engine runs at the ideal rpm. Each engine model is different, so the ideal rpm for one engine isn't the same for another. To determine your recommended vehicle gearing, contact your Cummins Automotive Business Manager who will calculate the engine rpm for a given cruising speed based on transmission gearing, axle ratio and tyre size.

The **startability** value represents the maximum grade on which the vehicle can move off when loaded to the specified vehicle weight using the lowest transmission gear ratio.

While the transmission's top gear ratio determines cruise rpm, startability is determined by the transmission's first or low gear ratio. This may not seem important for a highway vehicle, but pulling away from a loading dock/site or reversing can test the startability of a truck under adverse circumstances.

The power required to move the vehicle increases depending on the vehicle weight and the steepness of the grade. **Gradeability** is the vehicle's ability to climb a grade at a given speed. For example, a truck with a gradeability of 4% at 100 km/h can maintain 100 km/h on a 4% grade. Any steeper grade will cause loss of vehicle speed while climbing the hill.

If you spec too much horsepower, you encourage drivers to accelerate rapidly and drive faster (and have to brake more often), but speccing too little horsepower reduces gradeability and creates driver dissatisfaction and can increase trip times on hills.

Lubricants

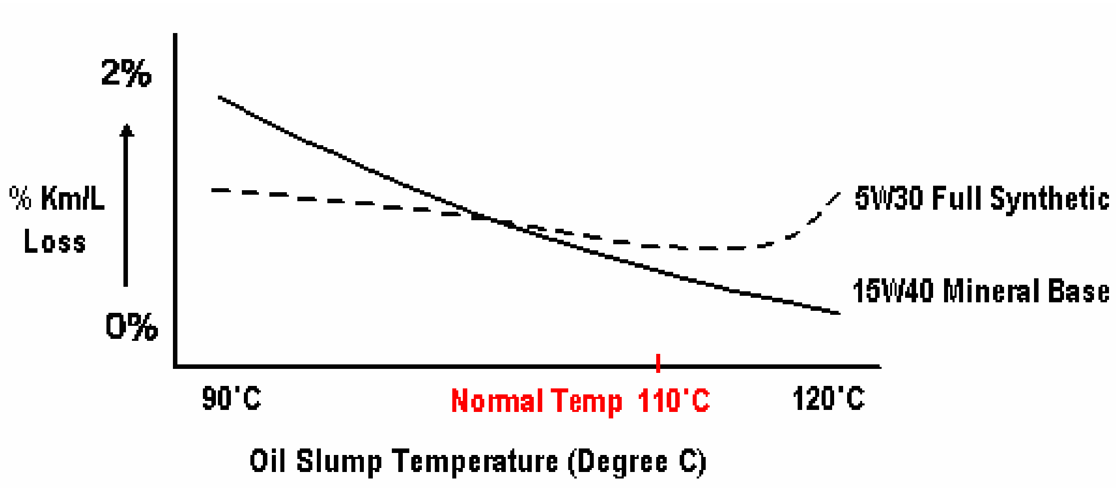
While the efficiency of drivetrain components is largely fixed by design, gross efficiency losses can be minimised through proper selection of lubricants.

Synthetic base lubricants are manufactured in the laboratory to exhibit superior high temperature stability and low temperature fluidity. Since these fluids are created to exhibit less thickening at low temperatures, pumping losses are reduced and substantial reductions in spin losses can be realised at low operating temperatures.

Test results indicate no significant difference in engine efficiency between synthetic and mineral base lube oils at normal operating temperatures. Since the synthetics are more expensive and, in an engine crankcase, are subject to the same contaminants as mineral-based oils, they may not be cost effective.

All oils thicken at low temperature, causing increased fuel consumption. The synthetic oil is less affected by temperature. This makes synthetic oils more fuel efficient at lower ambient temperatures.

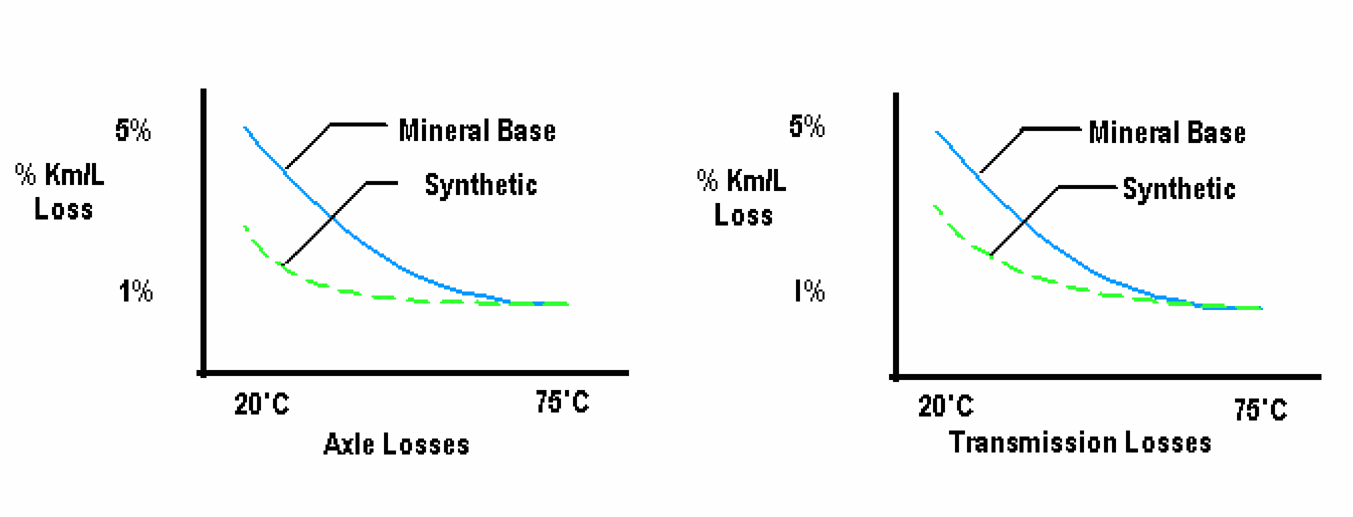
Effects of Lubricant Temperature and Performance



The high temperature stability and low temperature fluidity of synthetic lubricants make them ideally suited for drivetrain components. In this environment the lubricant is not subjected to combustion byproducts. This means the lubricant, with its higher oxidation resistance can last substantially longer and may offset the higher purchase price of the lubricant.

Dynamometer and on-highway vehicle testing have demonstrated significant benefits in fuel economy .

Lubrication versus axle and transmission losses

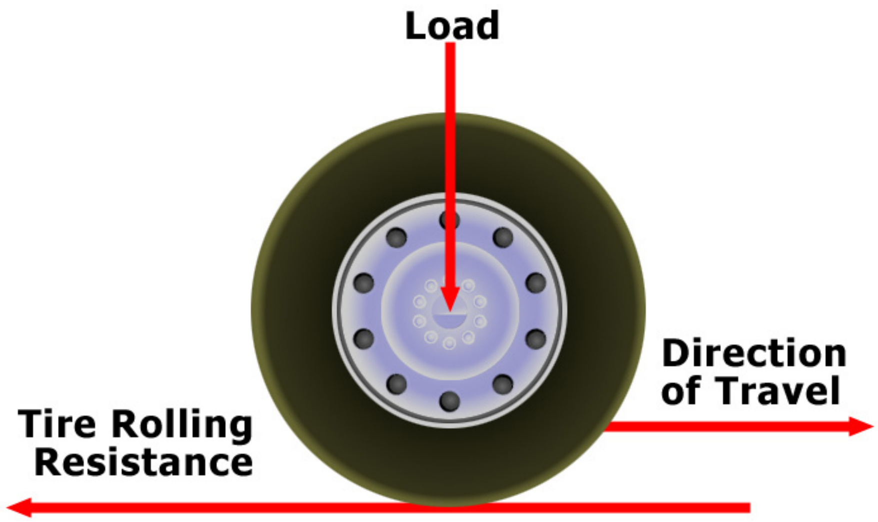


Tyre Rolling Resistance

Rolling resistance results from the internal friction of a tyre as it deflects (flexes) during motion. Energy spent generating heat in the tyres is energy that does not contribute to moving the vehicle. Cooler running tyres are more fuel-efficient than tyres that run hotter.

Complex rubber compounds, advanced casing construction and enhanced tread designs have led to new standards in tyre performance. Tyre rolling resistance is the second most significant contributor to vehicle power requirements. Tyre rolling resistance is influenced by multiple factors:

- Vehicle speed
- Load/GCM
- Inflation Pressures
- Tyre construction/tread type/depth
- Ambient temperature
- Road Surface
- Vehicle tyre and axle alignment



Vehicle Speed

- Tyres flex more at higher speeds. This leads to more friction, higher tyre temperatures and reduced fuel economy. Remember the rule that fuel economy goes down nearly 2% for every 2 km/h over 90 km/h. That rule takes tyre rolling resistance and aerodynamic drag into consideration.

Weight Impact

Increased weight causes increased flexing of the tyres. Reducing the weight of components on the truck can result in either better fuel economy, or increased payload for the same amount of fuel consumed. Of course, tyres should always be rated for the loads carried and properly inflated.

Table 3: The Role of Weight on Rolling Resistance

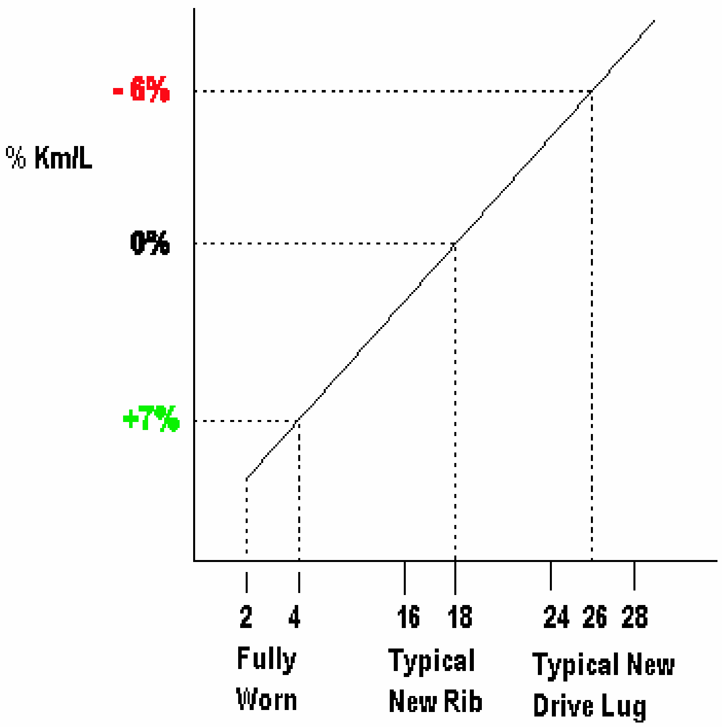
	Rolling Resistance Power Requirement (hp)
62.5 tonnes GCM	-109 hp
42.5 tonnes GCM	- 74 hp
	35 (hp difference)
Economy advantage assuming 250 hp road load:	~ 14% better mpg w/ lower GCM

Tread Depth and Pattern

Tyre tread accounts for 60% to 70% of the tyres' rolling resistance. Not only do the tyres differ in rolling resistance when new, but as the tread wears, the rolling resistance of the tyre reduces.

A 5mm tread wear represents a 10% reduction in rolling resistance (5% better economy) compared to a new tyre. Rib tyres at all wheel positions will provide greatest fuel efficiency.

Tread pattern is important because lugs have deeper tread (more rolling resistance) than ribs. If we take a new ribbed tyre as the standard, a new lugged tyre is less fuel efficient by about 6%. A worn tyre is about 7% more fuel efficient than a new tyre.



Rock-Solid Rule
Every 70 kPA (10 psi) of underinflation represents approximately 1% penalty in fuel economy.

Engine Operation and Maintenance

Getting the most out of the engine means running it at the right rpm. To truly optimise economy, you need to optimise several other engine operating characteristics.

Engine Operating Temperature (Coolant and Lube Oil)

Low coolant temperatures indicate an engine that is too cold for efficient combustion. Fuel liquefies on the cold cylinder walls and fails to burn. Of course, excess heat causes engine failure.

Lube oil below the ideal temperature is more viscous and harder to pump. Oil above the ideal temperature is too thin to lubricate properly. Either way, the engine suffers.

Coolant and lube oil operating temperatures can contribute greatly to fuel efficiency. Typical cooling system operating temperatures are above 80°C. A 0.4% fuel economy loss is associated with every 15°C decrease in temperature.

Lube system operating temperatures run above 105°C, and a 1% fuel economy loss is associated with every 15°C decrease in lube temperature.

Intake and Exhaust Restriction

An engine that is starved for air (intake restriction) or unable to expel exhaust (exhaust restriction) will lack power and waste fuel. The extra fuel burns inefficiently at best because it takes air to completely oxidise the fuel and extract all of the power that it contains.

Air Compressor Operation

While the air compressor's power demands are small compared with the fan, every little bit helps. Fixing air leaks can have a small but noticeable effect on economy.

Table 4: Air Compressor HP Requirements

	**Loaded*	*Unloaded*
RPM	HP	HP
1300	4.0	0.4
1500	4.5	0.5
1700	5.0	0.6
1900	5.5	0.8
2100	6.0	1.0

(*) Estimated hp draw with approximately 80 kPa (12 psi) manifold pressure pumping to 790 kPa (115 psi) with a single cylinder compressor

Typical air compressor duty cycles are as follows:

- Interstate / Line haul 10% - 15%
- Metro 20% - 30%
- Garbage Compactors 40% - 50%

The factors influencing excessive compressor operation include the following:

- Air system leaks
- Air ride suspension
- Excessive service brake use

These can result in a 2% to 4% worse economy when the air compressor is pumping.

Engine Lube Oil Levels

Exceeding the recommended engine oil levels can result in significant oil churning/spin losses. The effects of these excessive churning/spin losses (greater than 2% impact on economy) include the following:

- Reduced engine efficiency
- Reduction in performance
- Deterioration of critical oil properties (lubrication and heat transfer)

Fan Operation

The typical on-highway fan run time hits a year round average of 10%. It takes between 10 hp and 70 hp to drive the cooling fan. An inoperative fan clutch, faulty thermostatic switch, low coolant level or other malfunction that makes the fan run longer can take a big bite out of the fuel economy of the vehicle. Cooling system maintenance can have a significant effect on fuel economy.

Table 5: Typical Heavy-Duty Fan Power Requirements

RPM	*ISM (HP)*	*ISX/SIG (HP)*
1100	9	10
1300	14	17
1500	22	26
1700	32	37
1900	45	52
2100	61	70

At 1600 rpm cruise operation, the fan being locked on can cause an 10% to15% economy penalty.

High Air Intake Temperatures

The following systems <u>will bring the fan on automatically</u>.

- High cooling system temperatures
- High intake manifold (boost) air temperatures
- A/C Freon compressor activation

To minimise **Fan On Time**, operators must keep the charge air cooler clean and free from dust and grass seeds. Blow it out. Low pressure between the coolers cause dirt to be sucked in and fused to hot cooler fin surfaces, thereby acting like an insulating coating.

Freon Compressor Operation

Approximately 50% of total fan run time is attributed to the Freon compressor operation. Excessive fan operation may result from:

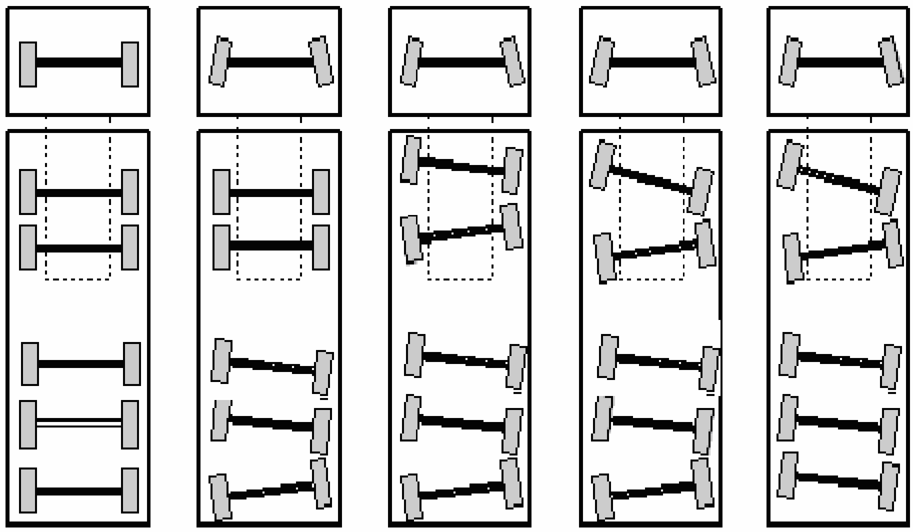
- An overcharged system
- Defective or incorrect head pressure switches
- Condenser efficiency

Axle Alignment

Tyres need to point straight ahead in order to roll with the least possible resistance. A tyre that deviates only ¼ degree from straight ahead will try to travel 2 m to 3 m sideways for each km the vehicle travels forward. Scrubbing the tyres in this fashion is bad for fuel economy and also bad for tyre wear.

This table shows the effect that some tyre misalignment has on fuel economy.

Table 6: Affects of Misalignment on Fuel Economy



Alignment	Test #1	Test #2	Test #3	Test #4	Test #5
Steer Tyre. Toe In:	0"	1/4"	1/4"	3/8"	3/8"
Drive Axle. Non-Parallel:	0"	0"	1/2"	1"	1"
Trailer Axle. Non-Parallel:	0"	1/2"	1/2"	1"	0"
% Effect on Economy	0.0%	-0.6%	-0.8%	-1.7%	-2.2%

Tyre Inflation Pressure

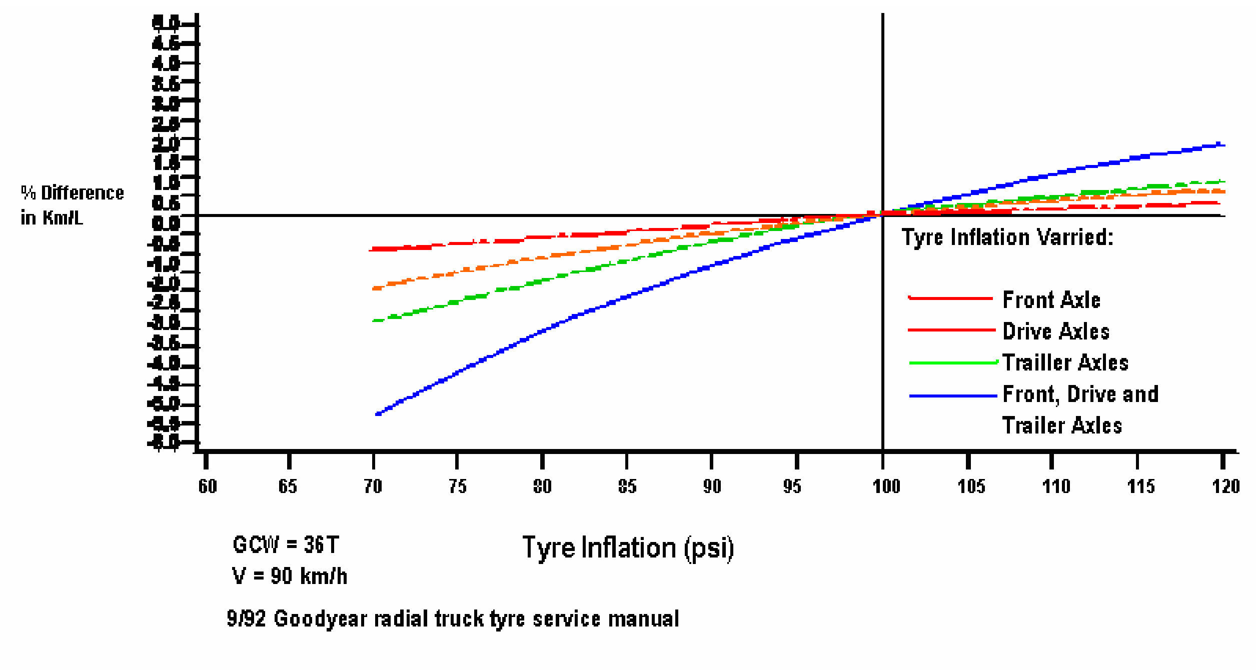
Proper inflation pressures critically affect tyre performance. Underinflation is detrimental to tyre performance and durability. Specifically, it:

- Reduces fuel economy
- Increases tyre wear rates
- Creates irregular tread wear
- Reduces casing durability

Every 70 kPa (10 psi) of underinflation represents approximately 1% penalty in fuel economy.

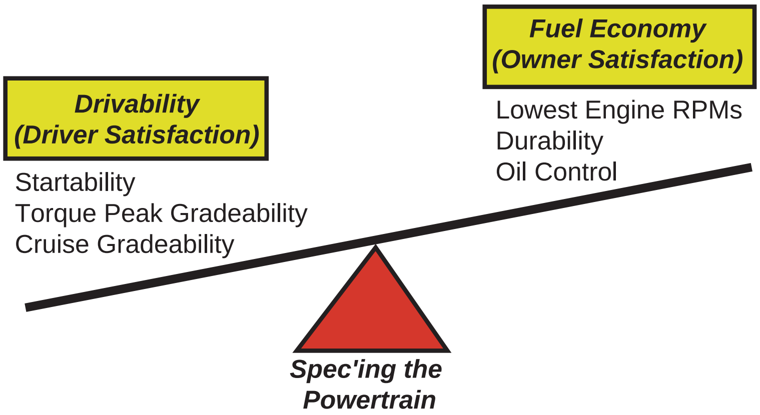
The effect of running all tyres slightly underinflated (blue line on the chart) is significant. But all tyres do not contribute equally. Notice that the trailer tyres (green line on the chart) have a larger effect on fuel economy than either steer or drive tyres. The tyres most likely to be ignored, poorly maintained or underinflated are in the trailer position, where old tyres with irregular wear are often placed to run out any remaining tread.

Radial Truck Tyre Inflation versus Percent Change in Economy



Powertrain Guidelines

Every engine has a sweet spot where it delivers its best fuel economy. To optimise fuel economy, the engine should run at this speed during normal highway cruising. When speccing the powertrain, two factors offset each other: consideration for the vehicle's performance (startability, gradeability and cruise speed) and consideration for the vehicle owner's desire to achieve fuel economy.



Carefully compare recommendations with existing equipment which should dictate minimum performance requirements.

Standard Heavy-Duty Gearing Recommendations

The ideal or preferred engine speed varies somewhat depending on the engine. The vehicle should be geared to operate at the manufacturer's recommended rpm at whatever road speed the vehicle will spend most of its time.

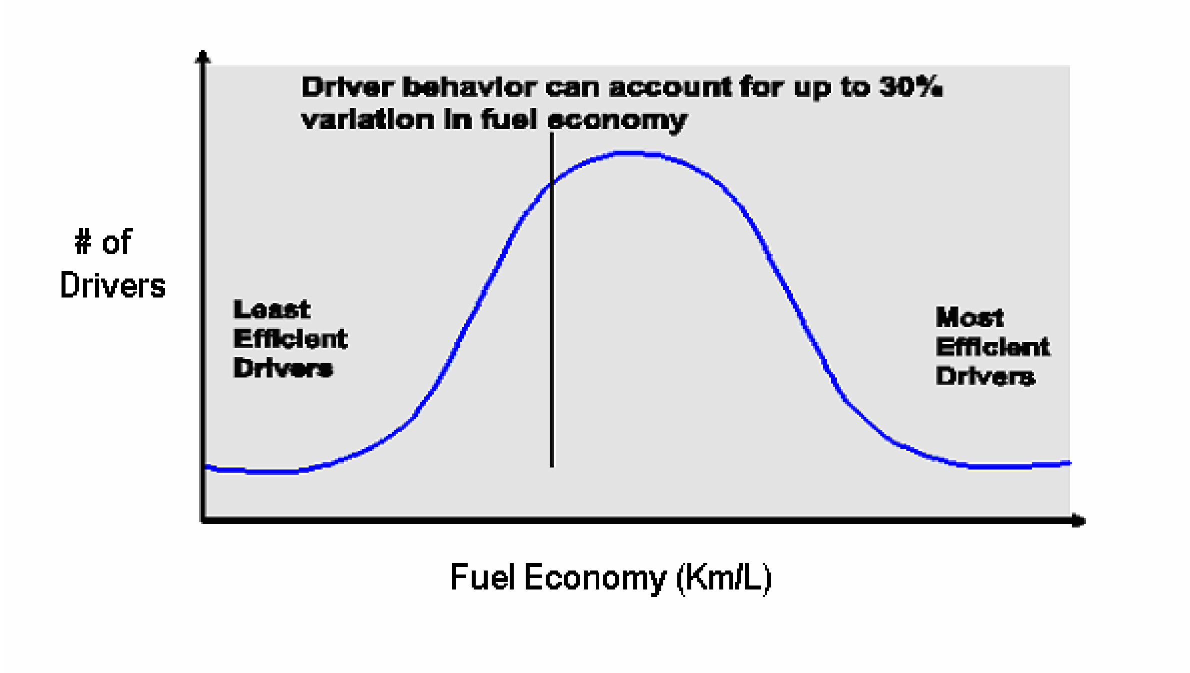
Approximate rpm on-highway gearing for Linehaul Applications at 100 km/h will be:-
- Single Trailer (less than 42t) 1500 to 1600 rpm
- B Double (less than 62 t) 1550 to 1650 rpm

Assuming the truck spends most of its time on interstate highways, these recommendations will optimise fuel economy.

Selection of the appropriate drivetrain components is critical to achieving driveability and economy goals.

Vehicle Operating Techniques

Excessive speed decreases fuel economy. In addition, excessive idling, operating the vehicle in the wrong gear and accelerating and decelerating rapidly all consume extra fuel. It has been estimated that proper driving technique can account for a 30% variation in fuel economy.



Efficient Driving Behaviour

The following is a short list of behaviours exhibited by those drivers who consistently obtain good fuel economy. Simple behaviours, like coasting to a stop instead of staying on the accelerator until the last minute and then braking hard, add up to significant fuel savings over thousands of kilometres.

- High average vehicle speeds with minimum time spent at maximum vehicle speed
- High percent trip distance in top gear (90+ % recommended)
- Skip/Progressive shifting
- High percent cruise control in flat terrain
- Minimum percent Idle/PTO operation
- Minimum service brake activity
  - Number of sudden decelerations
  - Service brake actuations/1000 km

<u>Rock-Solid Rule</u>
The most efficient drivers get about 20% better fuel economy than the least efficient drivers.

Pre-Trip Inspection

Conduct daily vehicle pre-trip inspections. Such inspections should include checks of the following:

- Engine lube oil level
- Tyre inflation pressures
- Service brake adjustment (* must be qualified)
- Air system leaks
- Coupling device

Inspections reduce the potential for unscheduled downtime or vehicle related accidents and improve fuel economy.

Road Surface

Even road surface has a documented effect on fuel economy.

Using new concrete as the standard baseline, worn or polished concrete is even better. All other road surfaces are worse, some substantially.

Table 7: Tyre Rolling Resistance Pavement Type and Condition versus Relative Rolling Resistance

Road Surface		*Relative Rolling Resistance %*
Concrete	polished (best economy)	–12%
	new	baseline
Asphalt	with finish coat	1%
	medium coarse finish	4%
	coarse aggregate	8%
Chip and Seal Blacktop (worst economy)		33%

Road roughness can increase rolling resistance up to 20% due to energy dissipation in the tyres and suspension (10% loss of economy).

Shifting Techniques

Proper operating techniques result in the lowest number of engine revolutions per kilometre to maximise economy.

Follow two general rules:

- Maximise the percentage of time in top gear.
- Use the full operating range of the engine before gearing down (especially when cresting hills).

The lower gears are good for power but not for economy. So when moving off, employ the progressive shifting technique, using as few revs as possible in low range to pick up momentum. The aim is to get the truck into high range (lowest rpm) as soon as possible.

Gear Down Protection is a feature that helps maintain time in top gear. GDP ensures that road speed one gear down from top is always less than the road speed limited setting. GDP also senses engine load to make sure that it doesn't limit engine speed when the downshift is justified due to heavy load.

Cruise Operation

Cruise control can be a great equaliser in level and slightly undulating terrain. While some of the best drivers may still be able to obtain better fuel economy without using cruise control, cruise control in general can make an average driver better. Do not use CC in hilly conditions.

Anticipating Change

The key to effective cruise operation is anticipating changes that may occur while driving on the open road. Maintaining a high field of vision and establishing proper following distances is a good start. Drivers should also do the following:

- Anticipate changes in traffic and road conditions
- Avoid abrupt stops or rapid changes in vehicle speed
- Minimise use of service brakes (plan ahead)

Automated Gearboxes

Although automated gearboxes can make driving easier, the driver must control when the gear changes occurs, to <u>maintain top gear as long as possible</u>. Especially in undulating or hilly terrain. The objective is to maximise time spent in the most fuel efficient engine rpm range. Manual manipulation of gear change points will improve fuel economy.

Vehicle Speed Management

The vehicle's road speed has a tremendous effect on fuel economy. As road speed increases, so does air resistance and rolling resistance. Thus, the power required to move the vehicle down the road increases. For example, at 90 km/h, you may get 2 km/litre; at 100 km/h, you'll get 1.8 km/litre (because it requires 30-40 hp more).

Rock-Solid Rule Above 90 km/h, each 2 km/h increase in vehicle speed decreases economy by nearly 2%.

Operation in Hilly and Mountainous Terrain

In rolling terrain, use a light throttle and allow momentum to carry the vehicle over short grades. In hilly and mountainous terrain, where possible, use the engine's entire operating range before gearing down. When cresting steep grades, use gravity to bring the vehicle back to the desired cruise speed.

Engine Idling

Idle time can significantly affect the vehicle's fuel efficiency. Therefore, avoid unnecessary engine idling. The vehicle gets its worst economy when the engine runs and the truck doesn't move. Every hour of idle time in a long-haul operation can decrease fuel efficiency by 1%.

Table 9: Idle/PTO Fuel Consumption

Engine Speed RPM	*Average Fuel Consumption (L/hr)*
650	1.9
1000	3.8
1200	5.6

Idle/PTO fuel consumption increases exponentially with engine speed (0–10% impact on economy). When idling is necessary, select the lowest idle speed possible (no higher than 800 rpm).

Recommend – Set the ECM Feature "Idle Shutdown" to prevent unnecessary idling.

Rock-Solid Rule
Idle time is costly. Every hour of idle time in a long-haul operation can decrease fuel efficiency by 1%.

Weather and Seasonal Conditions

You can't control the weather or the seasons, but they definitely affect your fuel economy so you have to take weather and seasonal variations into account when checking fuel economy.

Ambient Temperature

Air becomes more dense as temperatures drop, which increases air resistance. For every 5°C drop in temperature, aerodynamic drag increases by 2%. Thus, fuel efficiency will drop by 1%. Overall, fuel economy tends to be higher in the summer than the winter.

Temperature also affects the tyres' inflation pressure. Tyre inflation tends to fall when the temperature drops. Running tyres low on air pressure in hot weather is more of a safety issue than a fuel economy problem. And heat is the tyre's worst enemy. For safety and economy, check inflation pressures frequently with an accurate tyre gauge. When seasons change and temperatures fluctuate, increase the frequency of inflation pressure checks.

Wind

Headwinds and crosswinds can significantly increase aerodynamic drag and reduce fuel efficiency. For every 15 km/h of headwind or crosswind, economy is reduced by nearly 13%. You cannot cheat increasing wind resistance.

Rain and Snow

Precipitation such as rain or snow increases rolling resistance because the tyres must push their way through the water, slush or snow on the pavement. Also, water is a more effective coolant than air, so the tyres, transmission lubricant and axle lubricant operate at cooler (less efficient) temperatures. Rolling resistance and drivetrain friction in light rain increase fuel consumption by around 0.1km/litre.

Fuel Blends

While blended fuels provide better startability and protection against fuel gelling/waxing than standard No.2 diesel, fuel efficiency decreases. 'Summer' fuel improves economy up to 3% more than 'winter' fuel. Low sulphur fuels will further decrease economy.

Customer Fuel Consumption Effect Worksheet

Impact Cause	Special Notes	% Effect	% Customer Impact
Engine and driveline break-in effect	After 20,000 km the economy improves approx 2-5%	2% to 5%	
Tyre tread depth effect	Economy improves by approx 6% from 100% tread depth to 50% tread depth	0% to 6%	
Engine speed (proper gearing) effect	An engine geared to run at 1600 rpm at 100 km/h gets approx 2.5% better economy than one geared to run at 1700 rpm. If truck is geared to run too high it will force driver to run one gear down.	2.5%	
Aero effect	Full aero aids can improve economy by 15% above 80 km/h. Trailer gap must be minimised to less than 750 mm. Double trailers decrease economy by 5%. -ve effects can occur for irregular shaped loads on low loaders and drop decks	0% to 15%	
Winter effect	Higher density air, wind (cross and head), more idle time, blended fuel, rain, driveline drag etc – 8-15% less economy than in summer	8% to 15%	
Cooling fan effect	Fan hp increases with rpm. When fan is running it uses between 6 and 13 litres of fuel per hour. Increasing fan operation from 30 to 50% decreases economy by 3 to 5%.	3% to 5%	
Speed effect	Each 2 km/h increase in vehicle speed above 90 km/h decreases economy by nearly 2%. This is a rule of thumb that is hard to beat.		
Idle time % effect	Engine uses 1.9 l/hr at 650 rpm and 3.8 l/hr at 1000 rpm.	0% to 8%	
Driver variability effect	Up to 20% difference between good and poor economy drivers	0% to 20%	

General Information on Fuel Consumption

The Fuel Consumption: General Information section of the Troubleshooting and Repair Manual, Signature/ISX/QSX15 Engines, Bulletin 3666239 and Troubleshooting Excessive Fuel Consumption, Bulletin Number 3666094 should be referenced prior to any troubleshooting being performed on a customer's engine.

The cause of excessive fuel consumption is hard to diagnose and correct because of the potential number of factors involved. Actual fuel consumption problems can be caused by any of the following factors:

- Engine factors
- Vehicle factors and specifications
- Environmental factors
- Driver technique and operating practices
- Fuel system factors
- Low power/driveability problems

Before troubleshooting, it is important to determine the exact complaint. Is the complaint based on real or perceived problems or does it not meet the driver's expectations? The Fuel Consumption: Customer Complaint Form provides a valuable list of questions to assist the service technician in determining the cause of the problem. Complete the form before troubleshooting the complaint. The following are some of the factors to consider when troubleshooting fuel consumption complaints.

- Result of a Low Power/Driveability Problem: An operator will change driving style to compensate for a low power/driveability problem. Some of the things the driver will likely do include shifting to a higher engine rpm or running on the droop curve in a lower gear instead of upshifting to drive at part throttle conditions. These changes in driving style will increase the amount of fuel used.

- Driver Technique and Operating Practices: As a general rule, a 2 km/h increase in road speed equals nearly a 2% increase in fuel consumption. This means that increasing road speed from 90 to 100 km/h will result in an increase of 0.2 km/litre.

- Environmental and Seasonal Weather Changes: Generally, there can be as much as 0.4 to 0.6 km/litre difference in fuel consumption depending on the season and the weather conditions.

- Excessive Idling Time: Idling the engine can use from 1.9 to 5.6 litres per hour depending on the engine idle speed.
- Vehicle Aerodynamics: The largest single power requirement for a truck is the power needed to overcome air resistance. As a general rule, each 10% reduction in air resistance results in a 5% increase in economy.
- Rolling Resistance: Rolling resistance is the second largest consumer of power on a truck. The type of tyre and tread design have a sizeable effect on fuel economy and performance. Fuel efficient tyres have demonstrated gains as high as 0.2 km/litre.