

Comparison of Fuel Efficiency and Traction Performances of 6 × 4 and 6 × 2 Class 8 Tractors

Marius-Dorin Surcel and Yves Provencher
FPInnovations

ABSTRACT

The objective of this project was to compare the fuel consumption and traction performances of 6 × 2 and 6 × 4 Class 8 tractors. Two approaches have been considered: evaluation of 6 × 2 tractors, modified from 6 × 4 tractors, and evaluation of OEM 6 × 2 tractors. Compared to the 6 × 4 tractors, which are equipped with a rear tandem with both drive axles, the 6 × 2 tractors have a rear tandem axle with one drive axle, and one non-drive axle, also called dead axle. The 6 × 2 tractor configurations are available from the majority of Class 8 tractor manufacturers.

The SAE Fuel Consumption Test Procedures Type II (J1321) and Type III (J1526) were used for fuel consumption track test evaluations. Traction performances were assessed using pull sled tests to compare pulling distance, maximum speed, and acceleration when pulling the same set sled on similar surface.

Fuel consumption tests showed that 6 × 2 tractors consume up to 3.5% less than the similar 6 × 4 tractors, whilst pull sled tests showed shorter distance, lower maximum speed, and lower acceleration for the 6 × 2 tractors, when compared to similar 6 × 4 tractors. These differences are not critical or even not observable in normal operating conditions of on-highway transport but in specific conditions characteristic of particular northern operations, these differences could impact the performance of the tractor. However, systems are available for transferring the load from the dead axle to the drive axle in special conditions, for increasing the traction.

With 6 × 2 axles, traction tires can be installed only on the drive axle, while the dead axle can be equipped with more fuel-efficient tires, which can bring more fuel savings and tire cost savings. Another advantage is the weight reduction: it was shown that the 6 × 2 tractors were lighter than the 6 × 4 tractors, and reducing a vehicle's tare weight can translate into an increase in payload, which would enhance freight transportation efficiency.

At no additional cost, the 6 × 2 tractors replacing 6 × 4 Class 8 tractors could reduce annually the GHG emissions up to 1.93 tonnes per vehicle.

CITATION: Surcel, M. and Provencher, Y., "Comparison of Fuel Efficiency and Traction Performances of 6 × 4 and 6 × 2 Class 8 Tractors," *SAE Int. J. Commer. Veh.* 7(2):2014, doi:10.4271/2014-01-2358.

INTRODUCTION

Compared to the 6 × 4 Class 8 tractors, which are equipped with a rear tandem with both drive axles, the 6 × 2 Class 8 tractors have one driving axle and one non-driving axle, free rolling and load carrying only (also called dead axle), and depending on the position of the non-driving axle, there are two types of 6 × 2 tandems [1], as shown in [Figure 1](#):

- Tag tandem: forward axle of the tandem is driving type while rear unit is a dead axle.
- Pusher tandem: the rear most axle is driving type and the forward unit is a dead axle;

The 6 × 2 tractor configurations are available from the majority of Class 8 tractor manufacturers. The 6 × 2 and 4 × 2 configurations have been used extensively in Europe and other parts of the world for many years, but represents only 4% of tractor sales in the US market [2]. The total US market share of 6 × 2 Class 8 tractors is roughly 3% [3]. However, increase of orders from fleets and consequently in production were observed recently, due to potential fuel economy increases ranging from 2.5 to as much as 6% [4], [5]. Advances in electronics and controls are bringing the 6 × 2 tractors at similar operating performance with that of 6 × 4 tractors and require minimal driver interaction [2].

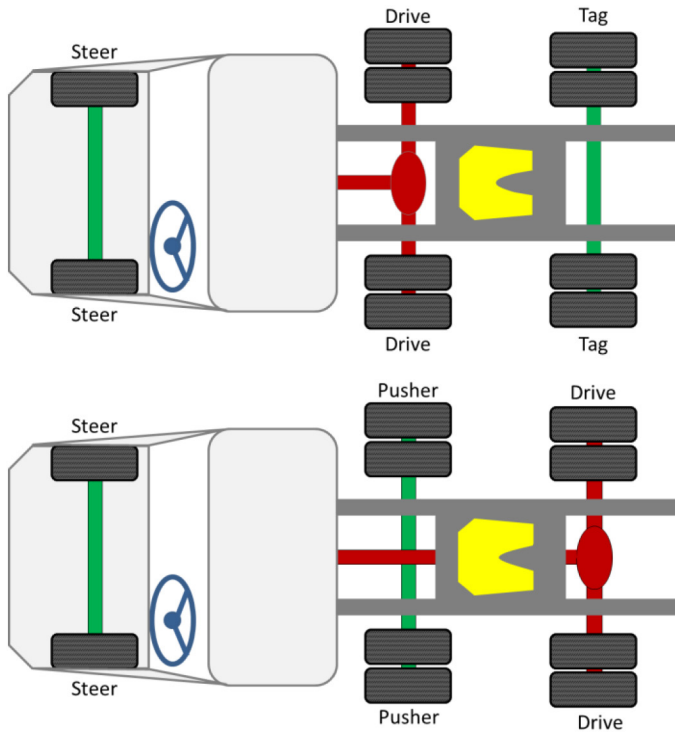


Figure 1. 6 × 2 tag and pusher tandems

Usually, the 6 × 2 systems are available in the same tandem ratings as the 6 × 4 arrangements, with the dead axle designed to carry the same load as the drive axle [2]. Obviously, the same ratings cannot be achieved with only one drive axle (4 × 2 configuration), even adding additional tires (which however is not technically feasible for drive axles on tractors), among others from road regulations considerations.

The objective of this project was to compare the fuel consumption and traction performances of 6 × 2 and 6 × 4 Class 8 tractors:

- Comparison of an OEM 6 × 2 tractor with a similar make and model 6 × 4 tractor;
- Evaluation of 6 × 2 tractors modified from 6 × 4 tractors. Two approaches for modifying the rear axles were considered:
 - Emptied rear housing, removed the drive shaft between front and rear housing, changed gears in the front housing but same ratio, 3.21 (Mod. 1). The gear set was changed to fit in the housing;
 - Switched front and rear housing, emptied rear housing; gears not changed, same ratio, 3.21 (Mod. 2).

TEST VEHICLES

Figures 2 and 3 present the test vehicles, and Tables 1 and 2 present vehicles data. These vehicles were used for both fuel consumption test and traction tests.



Figure 2. Test vehicles for modified 6 × 2 tractors.



Figure 3. Test vehicles for OEM 6 × 2 tractors.

Table 1. Vehicle data for modified 6 × 2 from 6 × 4 tractors

Vehicle	Control 6 x 4	Test 6 x 2 Mod1	Test 6 x 2 Mod2
Cargo Van, 2-axle			
Make, Model, Year	Kenworth T660, 2012		
No. of Drive Axles	2	2 (Base) / 1 (Final)	
Engine	Cummins ISX 15 42S, 2012		
Rated Power	336 KW(450 HP) / 1800 RPM		
Peak Torque	2239 Nm (1650 lb.-ft.) / 1000 RPM		
Transmission	Eaton RTL 0189 13A		
Differential	Dana Spicer D40-170P		
Differential Ratio	3.21		
Vehicle Test Weight	9025 kg (19897 lb.)	9264 kg (20423 lb.)	9282 kg (20463 lb.)
Steer / Drive tires	Michelin 275/80R22.5/XZA3 / Michelin 445/50 R22.5 X-One Line Energy XDN2		
Tire Pressure (cold)	690 kPa / 758 (100 / 110 psi)		
Trailer			
Make, Model, Year	Manac, 94253001, 2009		
Type	Cargo Van, 2-axle		
Truck Trailer Gap /	1219 mm (48 in.) / 737 mm (29 in.)		
Tires	Michelin 11R22.5 XZE		
Tire Pressure (cold)	690 kPa (100 psi)		
King Pin Setting	762 mm (30 in)		
Bogey Position	12.5 m (41 ft)		
Vehicle Test Weight	20865 kg (46000 lb.)	20156 kg (44500 lb.)	20838 kg (45940 lb.)

Table 2. Vehicle data for OEM 6 × 2 tractors

Vehicle	Control vehicle 6 x 4	Test vehicle 6 x 2
Tractor		
Make, Model, Year	Volvo VNL 64T, 2013	Volvo VNL 62T, 2013
No. of Drive Axles	2	1
Engine	Volvo D13, 2012	
Rated Power	317 kW (425 HP) / 2100 RPM	
Peak Torque	2373 Nm (1750 lb.-ft.) / 1050 RPM	
Transmission	ATO261D Volvo Auto	
Differential	Arvin Meritor MT40-14XC	Arvin Meritor RS23-160/161 plus Volvo non drive
Differential ratio	2.67	2.64
Vehicle test weight	8380 kg (18475 lb.)	8000 kg (17637 lb.)
Steer / Drive Tires	Bridgestone R283 295/75 R22.5 / Bridgestone M726EL 295/75 R22.5	
Tire Pressure (cold)	690 kPa (100 psi)	
Trailer		
Make, Model, Year	Manac, 94253001, 2009	
Type	Cargo Van, 2-axle	
Truck Trailer Gap /	1372 mm (54 in.) /	1270 mm (50 in.) /
Tires	Michelin 11R22.5 XZE	
Tire pressure (cold)	690 kPa (100 psi)	
King Pin Setting	914 mm (36 in.)	
Bogey position	12.5 m (41 ft.)	
Vehicle test weight	20865 kg (46000 lb.)	20883 kg (46040 lb.)

FUEL CONSUMPTION TESTS

Fuel Consumption Test Procedure

The test for comparing the 6 × 2 modified tractors with the original 6 × 4 tractors was based on the SAE J1321 Fuel Consumption Test Procedure - Type II [6]: the test compared the fuel consumption of a test vehicle operating under two conditions using an unmodified control vehicle. Fuel consumption was accurately measured by weighing portable tanks before and after each trip.

For each test, the control and test vehicles had the same general configuration and were coupled to the same semi-trailers for the base and test segments. The load weights remained the same throughout the entire test period. The vehicles were in good working condition, with all settings adjusted to the manufacturer's specifications.

The test consisted of a baseline segment (using non-modified vehicles) followed by a final segment (the test vehicles were modified, while the control vehicle stayed in its original state). For both the baseline and final segments, the representative results were the ratio between the average fuel consumed by the test vehicle and the average fuel consumed by the control vehicle (the T/C ratio).

The nominal values for fuel savings and for fuel improvement were determined from the analysis of the measured fuel data, and reflect the changes resulting from the modification being tested on the test vehicle. These nominal values consisted of the percentage difference between the final ratio $(T/C)_f$ and baseline ratio $(T/C)_b$:

- Fuel savings:

$$F_s = 100 * \frac{T/C_b - T/C_f}{T/C_b} \quad (1)$$

- Fuel improvement:

$$F_I = 100 * \frac{T/C_b - T/C_f}{T/C_f} \quad (2)$$

The result was expressed for the confidence interval level of 95%, complying with the SAE J1321 Fuel Consumption Test Procedure - Type II [6], and determined from the variation in the measured fuel consumption data relative to the nominal value and the number of data values obtained.

As for the test to compare 6 × 2 OEM tractor with 6 × 4 OEM tractor, it was based on the SAE J1526 Joint TMC/SAE Fuel Consumption Test Procedure - Type III [7]. This procedure compared the fuel consumption of one component of a combination vehicle to the same component in another combination vehicle, using portable tanks and the same gravimetric method as presented above.

The test consisted of a baseline stage followed by a final stage. The compared tractors were switched between the semi-trailers at mid-test. For each stage, the two test vehicles completed a minimum of three test runs until the results of a group of three runs were within 2% of each other. The total fuel consumed by the tractors when pulling the two semi-trailers was calculated: TFT for the test tractor when pulling the two semi-trailers, and TFC for the control tractor when pulling the two semi-trailers.

The results of the complete trial were expressed as fuel savings FS, the overall percentage difference between the total fuel consumed in both stages by the tractors when pulling the test semi-trailer versus the control semi-trailer:

$$F_s = 100 * \frac{TFT - TFC}{TFC} \quad (3)$$

Fuel Consumption Driving Procedure

Each day, before the start of testing, all vehicles were warmed up for the same amount of time (minimum one hour) at the test speed.