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FPInnovations FERIC

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Vol. 10 No. 5 July 2008

Contents



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# Track test evaluation of measures to reduce aerodynamic drag

**Abstract**

This study aimed to evaluate, in an accelerated manner, several aerodynamic drag reduction measures applicable to Class 8 tractor-trailer combinations. The tests were conducted according to SAE J1321 Joint TMC/SAE Fuel Consumption Test Procedure - Type II (SAE International 1986). The test results show up to 5% improvement in fuel consumption for the test vehicles equipped with boat tail devices, and up to 7% for the vehicles equipped with trailer skirts.

**Keywords:**

Aerodynamic drag, Boat tail, Chip vans, Trailers, Fuels, Tanks, Haul operations, Fuel consumption, Testing, Axles deflector, Trailer skirt, Greenhouse gases, Tractor trailer combinations.

## Introduction

Aerodynamic losses, engine losses, and tire-rolling resistance account for approximately 94% of the energy necessary to sustain vehicle speed at 100 km/h. Not considering the fuel expended in engine losses, aerodynamic drag is responsible for approximately half of the fuel consumed by a vehicle at highway speed. It has been estimated that decreasing drag by 25% can improve fuel economy by 10 to 15% (US Department of Energy, 2000). The aerodynamic devices tested included trailer aft body rear deflectors (boat tails), trailer skirts, gap deflectors, fuel tank fairings and truck rear-axle fenders. The aerodynamic influence of opened doors on an empty wood chip van trailer on the fuel consumption of the tractor-trailer combination was also assessed.

## Methodology

The fuel consumption testing took place on the high-speed test track (BRAVO) at the Transport Canada Motor Vehicle Test Centre (MVTC) in Blainville, Quebec. The track is a high-banked, parabolic oval measuring 6.4 km (4 miles) in length. Each test run was 100 km (approximately 15 laps).

Tables 1 and 2 present the specifications of the tractors and trailers used for the tests. For each technology tested, the control and test vehicles were always of the same make and model.

The long-haul fuel-consumption test was based on SAE J1321 (SAE International 1986), which provides a standardized test procedure for comparing the in-service fuel consumption of a test vehicle operating under two different conditions relatively to

**Table 1. Tractor specifications**

| Make and model | Peterbilt 387 | Volvo VNL 630 |
|---|---|---|
| Year | 2003 | 2005 |
| Engine | Caterpillar C12 | Cummins ISX |
| Rated power (kW) | 325 / 2100 rpm | 335 / 2000 rpm |
| Rated torque (Nm) | 2,100 | 2,100 |
| Transmission | Manual, RTLO-16913A | Automated, MO 16Z12A-A ZF MERITOR |
| Final ratio | 3.7 | 3.9 |
| Tires | 275/80 R22.5 | 275/80 R22.5 |
| Tire pressure (kPa) | 690 | 690 |
| Vehicle test weight (kg) | 8650 | 8550 |

**Table 2. Trailer specifications**

| Make and model | Manac 53' | Fericar F-CS-LB-4 |
|---|---|---|
| No. of axles | 2 | 4 |
| Type | Cube van 9425301 TRA/REM | Chip van (open top) |
| Tires | 275/80 R22.5, 445/50 R22.5 | 275/80 R22.5 |
| Tire pressure (kPa) | 690 | 690 |
| Vehicle test weight (kg) | 25 000 (loaded) | 7500 (empty) |

the consumption of a control vehicle. The only difference from the SAE J1321 test procedure was the structure of idle time. In order to minimize the probability of aborting runs because of no-start conditions, and to assure a sufficient distance between vehicles to avoid the effects of turbulence, all the vehicles participating in a test run turned on the engines simultaneously and they left the starting point at equal time intervals. At the end of the test run, each vehicle idled for the necessary period of time to assure that the total idle time was the same for all the vehicles.

An initial long-haul test was done before modifying the test truck. In this test, the control and the test trucks drive the test route several times until it can be statistically established that fuel consumption results are repeatable. The same trucks are then tested again, but this time the test truck is modified with the technology to be evaluated, and the control truck is left unmodified. For both the baseline and final tests, the representative result is the ratio between the average fuel consumed by the test truck and the average fuel consumed by the control truck. The results of the complete test trial consist of the percentage difference between the final ratio and baseline ratio.

The consumed fuel was measured using the gravimetric method with 145-L portable tanks equipped with quick-couplings, and a calibrated scale with a capacity of 150 kg and 0.05 kg resolution. The repeatability of the scale was periodically checked during the tests using a calibration weight set.

## Test results

Figures 1 to 8 present the devices tested and Table 3 provides the associated test results.

The test results show up to 5% improvement in fuel consumption for the test vehicles equipped with boat tail devices, and up to 7% for the vehicles equipped with trailer skirts.

**Table 3. Long-haul test results**

| Supplier | Technology | Fuel improvement (%) |
|---|---|---|
| Advanced Transit Dynamics | TrailerTails™ Boat tail | 5.1 |
| Freight Wing | Trailer skirts | 7.2 |
| Laydon Composites | Trailer skirts | 6.8 |
| Meka Form | Tractor fender | 1.4 |
| Transtex Composites | BoatTail, rear drag reduction device | 2.6 |
| Cascades Transport, in-house tests | Tank fairing | 1.0 |
| Cascades Transport, in-house tests | Tractor-trailer gap deflector | 1.0 |
| FPInnovations – Feric, in-house tests | Empty chip van, influence of opened doors on fuel consumption | 1.6 |

Figure 1. AT Dynamics trailer boat tail.


Figure 2. Freight Wing trailer side skirts.


Figure 3. Laydon trailer side skirts.

Figure 4. Meka Form drive axle fender.


Figure 5. Transtex trailer boat tail.

Figure 6. Cascades fuel tank fairing.


Figure 7. Cascades gap deflector.

Figure 8. FPInnovations – Feric and Transport Charette chip van opened doors.

## Economic and greenhouse gas (GHG) impact

Referencing the Canadian Vehicle Survey (Statistics Canada 2007) data for a tractor-trailer, the average yearly mileage is 95 300 km with 34 L/100 km being the average fuel consumption. Using a conservative approach, the test results were applied to the on-highway portion of the annual mileage only, which was estimated at 64 800 km per vehicle. The annual quantity of fuel consumed in these conditions would be 22 000 L per vehicle with an associated cost of $24 000 (for an average unitary price of $1.09/litre). Based on the aforementioned rationale, Table 4 provides estimates for the economic consideration of the various devices as well as the associated reductions in GHG emissions.

The GHG reduction potential on a Canadian scale is calculated using the assumption that these technologies would only be applied to 50% of the tractor-trailers (96 700 units); each litre of consumed diesel fuel produces 2.7 kg of the GHG $CO_2$ (National Resources Canada, 2008). These estimations show that some aerodynamic devices could reduce annual GHG emissions by as much as four tonnes per vehicle. With payback periods as low as 15 to 29 months, the majority of the tested aerodynamic devices represent viable measures to reduce GHG emissions.

## Implementation

- Provide support to fleets in developing truck specifications that include the devices showing positive results.
- Advise forestry operators in applying the findings regarding the influence of opened doors on empty wood chip van trailers on fuel consumption.
- Cooperate with aerodynamic device manufacturers to bring creative approaches to the on-highway forestry transportation market.

**Table 4. Economic and GHG impact (annualized)**

| Supplier | Technology | Cost ($) | Savings ($) | Payback period (months) | Saved fuel (L) | GHG reduction (kg/vehicle) | GHG reduction Canada (tonnes) |
|---|---|---|---|---|---|---|---|
| AT Dynamics | TrailerTails™ | 2000 | 1220 | 20 | 1120 | 3020 | 292 030 |
| Freight Wing | Trailer skirts | 2200 | 1730 | 15 | 1580 | 4270 | 412 910 |
| Laydon Composites | Trailer skirts | 2200 | 1630 | 16 | 1500 | 4050 | 391 640 |
| Meka Form | Tractor fender | 2950 | 340 | 104 | 310 | 840 | 81 230 |
| Transtex Composites | BoatTail | 1500 | 620 | 29 | 570 | 1540 | 148 920 |

## Conclusions

The tests indicate that the influence on fuel consumption was less than 2% for fuel tank fairings, truck rear-axle fenders, tractor-trailer gap deflectors, and opened doors on the empty chip van trailer. Test results show up to 5% improvement in fuel consumption for the test vehicles equipped with boat tail devices, and up to 7% for the vehicles equipped with trailer skirts.

In addition to major financial advantages, reducing fuel consumption also lowers vehicle emissions and demonstrates an environmentally responsible attitude. Combinations of different devices, such as trailer skirts and boat tails, would certainly increase the benefits even more. With payback periods as low as 15 to 29 months, the majority of the tested aerodynamic devices represent viable measures to increase fuel efficiency and reduce GHG emissions.

With increasing fuel costs and a strong commitment to reduce $CO_2$ emissions, aerodynamic drag reducing technologies can be solutions well worth considering. FPInnovations – Feric will continue to monitor developments in this area.

## Acknowledgments

This research program was partially funded by Transport Canada, the Ministère des Transports du Québec and the Agence de l'efficacité énergétique du Québec. The author would like to thank the technology suppliers for their enthusiastic participation: Advanced Transit Dynamics, Freight Wing, Laydon Composites, Meka Form and Transtex Composites. We would also like to extend our gratitude to Robert Transport and Cascades Transport, the fleets responsible for initiating and participating in the project, and to Transport Charette, which supplied the chip trailer for the tests. Furthermore, this project would not have been a success without the support of PMG Technologies, the operator of the test center.

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Publications mail #40008395 ISSN 1493-3381