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Energotest Fall 2011: Fuel Consumption Tests of the Ola Breau CERMA Product

Contract Report CR-656-14

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Introduction

The objective of the Energotest^{TM} project is to conduct controlled test-track studies of solutions for achieving higher fuel efficiency and lower emissions of greenhouse gases (GHG) in the trucking industry. Energotest not only allows fleets to choose the most efficient solutions, but also allows technology suppliers to better focus their development efforts. The 8th Energotest campaign was held September 20 to 23, 2011, at the Transport Canada Motor Vehicle Test Centre in Blainville, Quebec.

Technologies from seven suppliers were chosen for testing by Program Innovation Transport (PIT) partners. Ola Breau was among of the selected suppliers, and they submitted for testing the CERMA product, a ceramic treatment, which for the purpose of the testing was used according to the supplier's instructions: engine oil 340 grams (12 oz); power steering system 28 grams (1 oz); differential 170 grams (6 oz); trailer wheels 28 grams (1 oz) per wheel. According to the supplier, CERMA forms a micro-ceramic silicon carbide (SiC) seal on all metal parts. When used on engines, it would impede the formation of sludge and abrasive carbon, which would increase compression, power and torque, fuel economy and turbo life, while it would decrease emissions, black smoke, vibrations, wear, and turbo lag. When used on transmissions and differentials, CERMA would not allow the formation of sludge and varnish, which would restore fast smooth shifting.

Test Site

The fuel-consumption tests were performed on the high-speed test track (BRAVO) (Figure 1).

Figure 1. Transport Canada Motor Vehicle Test Centre in Blainville.

The track is a high-banked, parabolic oval that is 6.4 km (4 miles) long. The length of a test run was 15 laps (almost 100 km), with departure and arrival at the same position along the track.

Test Vehicles

Details of the vehicles configurations are given in Table 1. Figures 2 and 3 present the test vehicle and the control vehicle.

Table 1. Vehicle data

Parameters	***Vehicles***	
	Control	***Test***
Tractors		
Vehicle test ID	**C1**	**C11**
Vehicle fleet ID	**102907**	**102717**
VIN	4V4NC9EG69N262097	4V4NC9GGX7N386867
Make and model	Volvo	Volvo
Year	2008	2007
Engine make and model	Volvo D13	VED12
Rated power	280 kW (375 HP)	295 kW (395 HP)
Peak torque	1966 Nm (1450 lb-ft)	1966 Nm (1450 lb-ft)
Transmission	Volvo Auto AT02512C	RTLO 16913L
Differential ratio	3.55	3.7
Vehicle test weight	9030 kg	9072
Tires	Michelin 275/80 R22.5 XZA3; XDN2	
Tire pressure (cold)	690 kPa (100 psi)	
Trailers		
Vehicle test ID	**T5**	**T11**
Vehicle fleet ID	**413**	**812B682**
VIN	2M592161741096757	2M5921612X1061998
Make and model	Manac	Manac
No. of axles	2	
Year	2003	1999
Type	53-foot Cube Van	
Tires	BF Goodrich ST230 275/80 R22.5	Michelin XZA3, XDN2, XZE 275/80 R22.5
Tire pressure (cold)	690 kPa (100 psi)	
Vehicle test weight	20860 kg	20929 kg

Figure 2. Test vehicle.

Figure 3. Control vehicle.

Test Methodology

Fuel Consumption Tests

The test procedure was based on the SAE J1321 Joint TMC/SAE Fuel Consumption Test Procedure - Type II (SAE International 1986). The fuel-consumption test compared the fuel consumption of a test vehicle, operating under two conditions, with that of an unmodified control vehicle.

Fuel consumption was accurately measured by weighing temporary tanks before and after each trip. The repeatability of the scale measurements was periodically checked during the tests using a set calibration weight. Figure 4 presents an example of the installation of the portable tanks.

Figure 4. Example of the installation of the temporary fuel tanks.

For each test, control and test vehicles had the same general configuration and were coupled to the same semi-trailers for the base and test trials. 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 stage (using non-modified vehicles) followed by a final stage (using the test vehicle equipped with the technology to be tested). The baseline stage was conducted before installing the technology on the test vehicle. For this stage, the control and test vehicles completed a minimum of three test runs until the results of a group of three runs, expressed for each run as the ratio between the fuel consumed by the test vehicle and the fuel consumed by the control vehicle, were within 2% of each other. For the final stage, the test vehicle was equipped with the technology being tested, while the control vehicle stayed in its original state. As in the baseline stage, the vehicles completed the test runs a minimum of three times until the results of a group of three runs were within 2% of each other. For both the baseline and final stages, the representative results were the average ratio between the fuel consumed by the test vehicle and the fuel consumed by the control vehicle (the average T/C ratio). The result of the complete trial consisted of the percentage difference between the average final ratio $(T/C)_f$ and the average baseline ratio $(T/C)_b$:

$$P_d = 100 \times \frac{(T/C)_b - (T/C)_f}{(T/C)_b} \qquad (1)$$

Details of the baseline and final trials are presented in Appendix A.[1]

Driving Procedure

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

The driver's influence on the results was minimized as much as possible by conducting the tests on a closed circuit and by strictly controlling the driving cycle as follows:

- A fixed idling time was used.
- Drivers started with maximum acceleration.
- A cruising speed of 98 km/h was set.
- Drivers steered as close as possible to the painted line at the right side of the track, without touching it.
- Drivers maintained a constant driving speed.
- After the established test duration was complete, drivers stopped using the cruise control at the designated point.
- During deceleration, drivers used only the service brakes and did not accelerate.
- Once at the meeting point, the trucks idled for the same duration before stopping the engine.

The time interval between two consecutive trucks remained the same in order to avoid the effects of turbulence caused by other trucks and prevent multiple trucks from being present at the same place and time on the track. The driving cycle was controlled with two radars. A radar speed sign displayed the speed of oncoming vehicles using highly visible LEDs, and was checked by the test drivers at every lap. The other device was a radar gun, operated by the test personnel, and placed on the opposite side on the track. Drivers received instructions by two-way radio, to ensure that the speed of the vehicles and the distance between them on the track remained constant. The duration of the runs was also checked.

Test Equipment

The following equipment was used during the tests:

- Portable tanks with a capacity of 144 L (38 gallons): Norcan Aluminum 103461.
- Calibrated scale with a capacity of 226.80 kg and a resolution of 0.02 kg: Weigh-Tronix WI-152/DS, S/N 000341, calibration certificate dated May 9, 2011.
- Weather station: Davis Instrument Vantage Vue.

The repeatability of the scale measurements was periodically checked during the tests using a calibration weight set.

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[1] Discrepancies in odometer readings between the vehicles resulted from inaccuracy of these instruments.

Test Results

Fuel Consumption Test Results

The baseline stage was conducted on September 20, 2011 before treating the test vehicle with the CERMA product. After the baseline test, the test vehicle was treated with the CERMA product under the supervision of the supplier's representative. The final stage was on September 23, 2011: between the baseline and the final test, the test vehicle accumulated 1,411 km of break-in distance. For both tests stages, three valid ratios between the two vehicles' fuel consumptions were obtained with three test runs.

The CERMA products showed 2.1% fuel savings. Table 2 summarizes the results and details are presented in Appendix B.

The repeatability of the tests can be evaluated using the coefficient of variation (c_V), which is defined as the percentage ratio of the standard deviation (σ) to the mean (μ):

$$c_V = 100 \times \frac{\sigma}{\mu} \tag{2}$$

As can be seen in Table 2, the coefficients of variation for T/C ratio were 0.43 and 0.06 %, which shows very good consistency and repeatability of the tests.

Table 2. Summary of test results for the CERMA product

Baseline stage, September 20, 2011				**Final stage, September 23, 2011**			
Valid test runs	Consumed fuel, kg		T / C ratio	Valid test runs	Consumed fuel, kg		T / C ratio
	Control vehicle C1-T5 (102907-413)	Test vehicle C11-T11 (102717-812B682)			Control vehicle C1-T5 (102907-413)	Test vehicle C11-T11 (102717-812B682)	
1	30.54	33.32	1.091	1	30.32	32.46	1.071
2	30.10	33.10	1.100	2	30.08	32.24	1.072
3	30.34	33.14	1.092	3	29.68	31.80	1.071
Average T/C ratio							
1.094				1.071			
T/C ratio coefficient of variation, %							
0.43				0.06			
Fuel saved, %							
2.102							

Discussions

Discussion of Test Limitations

Road tests and track tests are subject to variations in conditions between runs, and controlling or accounting for these variables as much as possible is an important part of ensuring accurate results.

Air density varies with temperature, relative humidity and barometric pressure, and changes in air density affect aerodynamic resistance. Ambient temperatures, humidity, barometric pressure, and wind speeds and directions were measured at the test site and these data were verified using climate data from the Mirabel Airport (Environment Canada) weather station, located 12 km from the test site. The density of the air can be computed from measurements of these parameters (Surcel et al. 2008). Figure 6 presents the variation in air density during the testing of the CERMA product. It can be observed that the maximum difference in air density between baseline and final stages during the tests was 0.012 kg/m^3. As shown in Appendix A, the maximum wind speed observed during the tests was 6 km/h, which is much less than the acceptable limit of 20 km/h (EPA 2011). Moreover, in order to minimize the effects of wind yaw angle, a closed-loop parabolic oval was used.

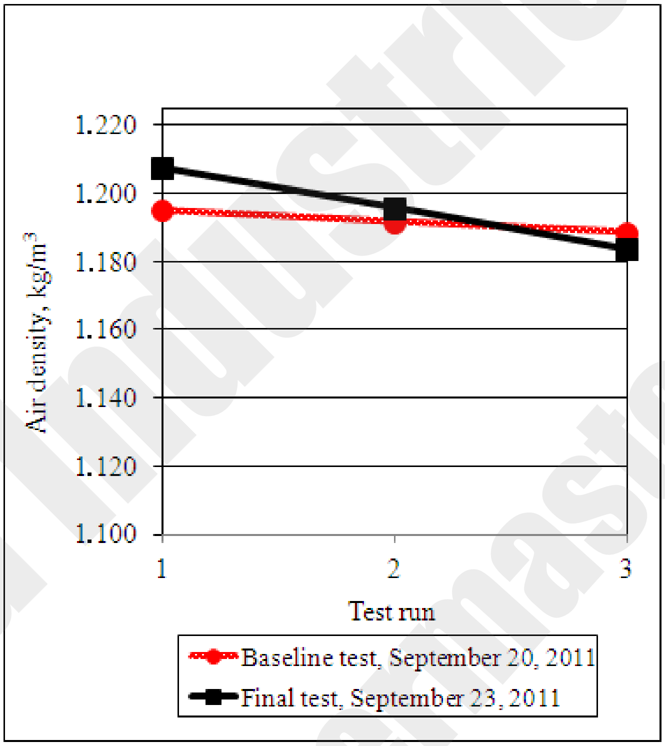

Figure 6. Air density variations during CERMA product testing.

The only possibility for minimizing the influence of varying ambient conditions is to use unchanged control and test vehicles (with the exception of the modification being tested on the test vehicle), with the assumption that both vehicles will be equally affected by these variations. For this purpose, the test and control vehicles were of the same general configuration and confirmed to be in proper operating condition prior to and during the tests. The trailers were matched to each test and the control vehicles remained matched with their respective tractors throughout the entire series of tests.

Another variable was the driver. Testing took place on a closed test track at a fixed speed of 98 km/h, with a standard acceleration and braking protocol for all drivers, in order to eliminate the influences of traffic and variations in driver response. In addition, travel speeds were monitored throughout the trials using radars, and drivers were instructed by radio if it became necessary to adjust their travel speed. The driver's influence on the results was thus minimized as much as possible by strictly controlling the driving cycle.

To minimize measurement uncertainties, the only measured parameter used to calculate the test results was the weight of the portable tanks. Other parameters, such as vehicle speed, distance and time, were recorded for information purposes only. In order to avoid potential problems related to the instruments, two recently calibrated scales were available on-site. For each run, the portable tanks were weighed using the same portable scale. Furthermore, the scale was periodically checked against a known weight of 80 kg. The portable scale was not moved between the initial and final weighing for a given test run. Distance measurement was not a factor because for each run, all vehicles departed and arrived at the same point after travelling the same number of laps and following the same path along the track.

Discussion and Recommendations Regarding the Tested Technology

There is no doubt that reducing friction in the engine, or transmission will reduce the fuel consumption. Fuel efficient engine lubricants can be obtained by reducing the viscosity (which favors pistons and bearings) whilst at the same time adding an effective friction modifier (which gives benefits in the valve train). However, it is still necessary to pass all other relevant engine tests, desirable to have low volatility, and it is essential that engine durability is maintained. Other formulation factors also affect the fuel savings achieved, and engine design and driving cycle have big influences on the effectiveness of the lubricant in reducing fuel consumption: higher fuel savings are more likely to be achieved for the vehicle making numerous short trips (Taylor and Coy 2000).

Conclusions

The percentage fuel saving difference between the final ratio[2] and baseline ratio[3] was 2.1% for the test vehicle using the CERMA product. .

Disclaimer

This result refers only to the vehicle and specimen of technology tested according to the procedure and conditions described in this report. FPInnovations cannot guarantee the reproducibility of this result in particular operating conditions.

Ola Breau assisted during the two stages of tests performed on their product and validated the installation of their product on the vehicle used to perform the tests, prior to the beginning of said tests. Ola Breau also acknowledged that the tests were conducted in conformity with the test protocol.

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[2] The average mass of fuel consumed by the test vehicle in the final test / average mass of fuel consumed by the control vehicle during the final test.

[3] The average mass of fuel consumed by the test vehicle in the baseline test / average mass of fuel consumed by the control vehicle during the baseline test.

References

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Appendix A: Test trial forms

ENERGOTEST 2011	**TEST TRIAL FORM**

Date: September 20, 2011 **Trial:** **BASE** **Vehicle:** ***Test Vehicle***
C11-T11 (102717-812B682)

Supplier: Ola Breau
Technology: CERMA
Meteorological conditions:

Run	*Temp. (^0C)*	*Wind speed (km/h)*	*Wind direction*	*Relative humidity*	*Weather*
1	18.0	5	W	89	Mostly cloudy
2	19.0	3	NW	78	Mostly cloudy
3	20.0	6	W	68	Mostly cloudy
4					
5					
6					

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Time	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*
1	8	11:54:00	831600.7	95.40	12:57:00	831701.7	62.08	01:03:00	101.0	33.32
2	FR11	13:17:00	831701.7	98.12	13:20:11	831802.6	65.02	00:03:11	100.9	33.10
3	8	14:37:00	831802.6	82.62	15:40:11	831903.5	49.48	01:03:11	100.9	33.14
4										
5										
6										

Autofill after each row

Observer	***Marius-Dorin Surcel, Eng. (135765); Bernard Ouellet***
Prepared by	***Marius-Dorin Surcel, Eng. (135765)***

ENERGOTEST 2011 **TEST TRIAL FORM**

Date: September 20, 2011 **Trial:** **BASE** **Vehicle:** ***Control Vehicle***

C1-T5 (102907-413)

Supplier: Ola Breau Representing Cerma Industries

Technology: CERMA with STM-3

Meteorological conditions:

Run	*Temp. (^{0}C)*	*Wind speed (km/h)*	*Wind direction*	*Relative humidity*	*Weather*
1	18.0	5	W	89	Mostly cloudy
2	19.0	3	NW	78	Mostly cloudy
3	20.0	6	W	68	Mostly cloudy
4					
5					
6					

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Time	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*
1	2	11:52:00	514800	112.12	12:55:00	514901.2	81.58	01:03:00	101.2	30.54
2	6	13:15:00	514901.2	97.44	14:18:10	515002	67.34	01:03:10	100.8	30.10
3	2	14:35:00	515002	81.58	15:38:08	515102.7	51.24	01:03:08	100.7	30.34
4										
5										
6										

Autofill after each row

Observer	***Marius-Dorin Surcel, Eng. (135765); Bernard Ouellet***
Prepared by	***Marius-Dorin Surcel, Eng. (135765)***

ENERGOTEST 2011 **TEST TRIAL FORM**

Date: September 23, 2011 **Trial:** FINAL **Vehicle:** *Test Vehicle*

C11-T11 (102717-812B682)

Supplier: Ola Breau Representing Cerma Industries

Technology: CERMA with STM-3

Meteorological conditions:

Run	*Temp. (^{0} C)*	*Wind speed (km/h)*	*Wind direction*	*Relative humidity*	*Weather*
1	17.0	3	N	83	Mainly Clear
2	20.0	2	E	68	Mainly Clear
3	23	3	N	54	Clear
4					
5					
6					

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Time	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*
1	FR11	08:06:30	833314.7	102.80	09:09:32	833415.8	70.34	01:03:02	101.1	32.46
2	71	09:21:30	833415.8	101.78	10:24:39	833516.9	69.54	01:03:09	101.1	32.24
3	2	10:35:30	833516.9	99.28	11:38:38	833617.9	67.48	01:03:08	101.0	31.80
4										
5										
6										

Autofill after each row

Observer	***Marius-Dorin Surcel, Eng. (135765); Bernard Ouellet***
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ENERGOTEST 2011 **TEST TRIAL FORM**

Date: September 23, 2011 **Trial:** FINAL **Vehicle:** ***Control Vehicle***
C1-T5 (102907-413)

Supplier: Ola Breau representing Cerma Industries

Technology: CERMA with STM-3

Meteorological conditions:

Run	*Temp. (^0C)*	*Wind speed (km/h)*	*Wind direction*	*Relative humidity*	*Weather*
1	17.0	3	N	83	Mainly Clear
2	20.0	2	E	68	Mainly Clear
3	23.0	3	N	54	Clear
4					
5					
6					

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Time	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*	*Time*	*Odometer (km)*	*Fuel tank weight*
1	T1	08:04:00	516279.4	106.08	09:07:09	516380.4	75.76	01:03:09	101.0	30.32
2	F4	09:19:00	516380.4	106.74	10:22:01	516481.2	76.66	01:03:01	100.8	30.08
3	8	10:33:00	516481.2	97.98	11:36:07	516582	68.30	01:03:07	100.8	29.68
4										
5										
6										

Autofill after each row

Observer	***Marius-Dorin Surcel, Eng. (135765); Bernard Ouellet***
Prepared by	***Marius-Dorin Surcel, Eng. (135765)***

Appendix B: Test result form

ENERGOTEST 2011	**TEST RESULTS FORM**

Technology: **CERMA** with STM-3
Supplier: **Ola Breau**

RESET BASE DATA

VALIDATE BASE DATA

BASE TRIAL **DATE:** September 20, 2011

T/C ratio calculation					
Test run	*Consumed fuel (kg): vehicle "**C**"*	***C1-T5 (102907-413)***	*Consumed fuel (kg): vehicle "**T**"*	***C11-T11 (102717-812B682)***	*T / C ratio*
1	30.540		33.320		1.091
2	30.100		33.100		1.100
3	30.340		33.140		1.092
4					
5					
6					

Valid test runs and T/C average (T/CavB)			
Test run	1	2	3
T/C ratio	1.091	1.100	1.092
T/CavB	1.094		

RESET FINAL DATA

VALIDATE FINAL DATA

TEST TRIAL **DATE:** September 23, 2011

T/C ratio calculation					
Test run	*Consumed fuel (kg): vehicle "**C**"*	***C1-T5 (102907-413)***	*Consumed fuel (kg): vehicle "**T**"*	***C11-T11 (102717-812B682)***	*T / C ratio*
1	30.320		32.460		1.071
2	30.080		32.240		1.072
3	29.680		31.800		1.071
4					
5					
6					

Valid test runs and T/C average (T/CavT)			
Test run	1	2	3
T/C ratio	1.071	1.072	1.071
T/CavT	1.071		

TEST RESULTS

Parameter	***Notation***	***Equation***	***Value***
Base trial T/C average	T/CavB		1.094
Test trial T/C average	T/CavT		1.071
Percent fuel saved	PS	100(T/CavB - T/CavT) ÷ T/CavB	2.102

Prepared by	***Marius-Dorin Surcel, Eng. (135765)***