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Contract report 942-02 (Addendum 3):

Fuel Consumption and Emissions Tests of the HydraGen™ Technology from Dynacert

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Phone: 1-514-782-4520
Toll-free: 1-855-472-1159
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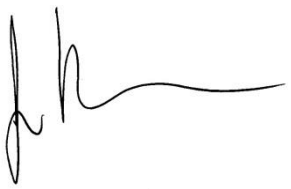
REPORT APPROVAL FORM

REPORT TYPE :	**Contract report 942-02 (Addendum 3)**
# PROJET*:*	**301012126**
TITLE :	**Fuel Consumption and Emissions Tests of the HydraGen™ Technology from Dynacert**
COMPANY	**Dynacert, 101-501 Alliance Ave., Toronto, Ontario, Canada, M6N 2J1**
DATE :	**November 8, 2017**
REVIEWER *:*	**Jan Michaelsen, F.E., Research Leader Transport and Energy, Interim Research Leader PIT Group**

SIGNATURES



Jan Michaelsen, F.E., Research Leader Transport and Energy, Interim Research Leader PIT Group

Date : November 8, 2017

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Contract report 942-02 (Addendum 3):

Fuel Consumption and Emissions Tests of the HydraGen™ Technology from Dynacert

Marius-Dorin Surcel,
Eng., M.A.Sc. (135765)

November 8, 2017

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Discover the PIT Group

PIT Group is one of eleven research groups of FPInnovations, which has over 400 employees at six main offices all across Canada and in the United States, as well as in regional offices located in each Canadian province.

PIT Group's team of researchers has been active in the field of transportation for over 35 years. This team's mission is to improve each phase of the transportation system, cut costs and emissions, and increase the safety of operations.

By working together and by using the most recent technological and operational innovations, our world-class professionals specialize in delivering concrete solutions at reasonable costs, as we are a non-profit research and development institute.

As part of services offered to clients, PIT Group supports fleets and suppliers, implements solutions for specific problems, and develops combined integrated solutions for more complex problems depending on clients' needs.

ISO 17025 certified tests

The Standards Council of Canada (SCC) granted the ISO/IEC 17025:2005 (CAN-P-4E) accreditation for tests conducted by PIT Group. This standard is the international reference for testing laboratories, and it is rarely granted to tests conducted outside of laboratories.

PIT Group testing activities under the ISO 17025 certification include fuel consumption testing for heavy-duty vehicles, such as testing according to SAE J1321 and TMC Fuel Consumption Test Procedure - Type II, SAE J1526 Fuel Consumption Test Procedure (Engineering Method), and TMC Fuel Consumption Test Procedure – Type III, EPA SmartWay Test Methods, fuel consumption testing for light-duty vehicles, and emissions testing using portable emission measurement system (PEMS) according to EPA regulations.

Our mission

Innovative, world-class engineering group contributing toward the development and accelerated implementation of safe, sustainable, and efficient technologies that support excellence in North America's transportation industry.

Strategy

To be the information hub among technology suppliers and carriers:

1. The most efficient, productive fleets rely on our indisputable findings to select the technologies that will give them a substantial competitive edge.
2. The most innovative technology suppliers bank on our expertise and our in-depth knowledge of the needs of fleets to develop better products.
3. We create alliances with the best organizations in the world to push the limits of technological innovation in sustainable and smart mobility.

Table of contents

List of figures

List of tables

Context

Dynacert, based at 101-501 Alliance Ave., Toronto, Ontario, Canada, M6N 2J1 , mandated FPInnovations PIT Group to conduct testing to evaluate the impact on fuel consumption and emissions of the HydraGen™ technology. This testing program was based respectively on the TMC Fuel Consumption Test Procedure – Type II, RP 1102A (TMC 2016a), and CFR (Code of Federal Regulation), Title 40 Part 1065, Engine Testing Procedures, Part 1065 - Subpart J PEMS Testing (CFR 2008).

This report presents the tests of contract 942 -02 - Addendum 3, as well as the first phase of the testing for contract 942-02, which was originally presented in Contract Report 942-02 (Surcel 2017).

Technology

HydraGen™ technology is designed for on-road applications with Class 6 - 8 vehicles. According to the manufacturer, HydraGen™ is a portable, safe and reliable aftermarket unit that produces hydrogen and oxygen on demand, from the electrolysis of distilled water. The addition of hydrogen and oxygen gases through the air intake would improve the combustion resulting in a more complete fuel burn which would deliver increased fuel economy, increased torque, lower emissions, and extend engine oil life. The system runs directly from the vehicles power system providing for high electrical efficiency and shuts off when the truck key is off.

Methodology

Test site

The tests were performed at the Transport Canada Motor Vehicle Test Centre located at 100 rue du Landais, Blainville (QC), Canada, J7C 5C9, which is presently operated by PMG Technologies (Figure 1).

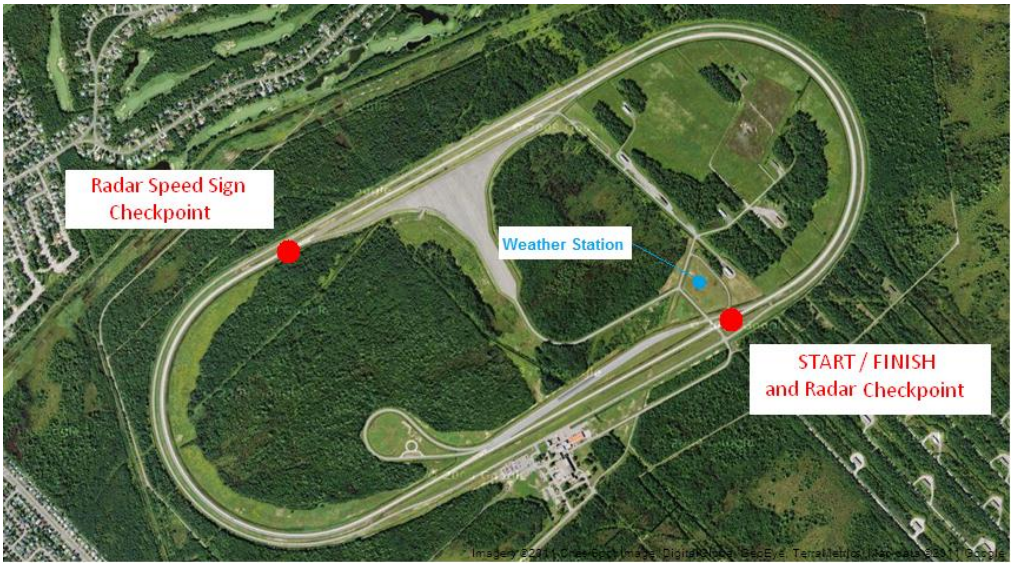

Figure 1. Test site with radar checkpoints and weather station positions.

The fuel consumption tests were conducted on the BRAVO high-speed test track, a high-banked, parabolic oval, with the length of 6.66 km (4.15 miles). The emission measurements were performed on the ALPHA low-speed test track, a parabolic oval with the length of 6.88 km (4.28 miles).

Test vehicles

Vehicle configurations are presented in Table 1. Figures 2 and 3 present photos of the test and control vehicles.

Table 1. Vehicle data

Parameters	*Test vehicle*	*Control vehicle*
Tractors		
Vehicle test ID (fleet ID)	**C6 (2243)**	**C7 (2240)**
VIN	3HSDJAPR4FN144571	3HSDJAPR1FN181450
Make and model	International Prostar+	
Build year (model year)	2014 (2015)	
Engine make and model	Cummins ISX15	
Emission label info	EPA 2015	
Rated power	336 kW (450 hp) / 1800 rpm	
Peak torque	2237 Nm (1650 lb-ft) / 1000 rpm	
Transmission	Eaton Fuller 18-speed	
Differential make and model; ratio	MT40-14X*D; 3.90	
Tires	Michelin 11R22.5	
Tire pressure (cold)	690 kPa (100 psi)	
Test weight	9010 kg (19864 lb)	8930 kg (19687 lb)
5th wheel setting	203 mm (8 in)	
Trailers		
Vehicle test ID	**T8**	**T9**
Vehicle fleet ID	**343**	**344**
VIN	2M592161791121504	2M592161191121501
Type, make and model	53-ft Cube Van, Manac 94253001	
No. of axles	2	
Build (model) year	2008 (2009)	
Tires	Michelin 455/50R22.5 XTE	
Tire pressure (cold)	690 kPa (100 psi)	
Truck trailer gap; aerodynamic gap	1422 mm (56 in); 965 mm (38 in)	1473 mm (58 in); 1016 mm (40 in)
King Pin Setting	914 mm (36 in)	
Bogey position	12.19 m (40 ft) (to the centre of the rear axle)	
Test weight	20850 kg (45966 lb)	20840 kg (45944 lb)
Total test weight	29195 kg (64364 lb)	29270 kg (64529 lb)

Figure 2. Test vehicle C6-T8.

Figure 3. Control vehicle C7-T9.

Fuel consumption test procedure

The test procedure was based on TMC Fuel Consumption Test Procedure – Type II, RP 1102A (TMC 2016). The tests were conducted in test conditions according to this recommended practice, which aims to obtain results that can be considered representative of actual service conditions: this applies to load, weather, wind, etc.

The fuel consumption tests were conducted on the BRAVO high-speed test track. The length of a test run was 15 laps (100 km), with departure and arrival at the same position along the track.

According to the TMC Fuel Consumption Test Procedure – Type II, RP 1102A (TMC 2016), the test compared the fuel consumption of a test vehicle operating under two conditions versus an unmodified control vehicle. Fuel consumption was accurately measured by weighing portable tanks before and after each run. The repeatability of the scale measurements was periodically checked during the tests using a set calibration weight. Figure 4 shows the installation of the portable tanks.

Figure 4. Installation of the portable fuel tanks.

Control and test vehicles had the same general configuration and were coupled to the same semi-trailers for the baseline and test segments. The vehicle weights remained the same throughout the entire test segment. 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 two test segments (the technology being tested, the HydraGen™, was used on the test vehicles while the control vehicle stayed in its original state). For all segments, the representative results were the ratio between the average fuel

consumed by the test vehicles and the average fuel consumed by the control vehicles (the T/C ratio). Results were expressed with a confidence interval of 95%, which was determined from the variation in the measured fuel consumption data relative to the nominal value and number of data values obtained. The fuel savings (F_S) and fuel improvement (F_I) were determined by analyzing 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 baseline segment ratio $(T/C)_b$ and the test segment ratio $(T/C)_t$:

- Fuel savings :

$$F_S = 100 * \frac{(T/C)_b - (T/C)_t}{(T/C)_b} \quad (1)$$

- Fuel improvement :

$$F_I = 100 * \frac{(T/C)_b - (T/C)_t}{(T/C)_t} \quad (2)$$

Driving procedure

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

The driver's influence on the results was practically eliminated 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 105 km/h (65 mph) 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 using the cruise control.
- 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 finish point, the trucks idled before the engines were turned off. All the vehicles in a test run idled for the same duration during the run.

The time interval between two consecutive trucks remained the same in order to avoid the effects of turbulence caused by other trucks and to prevent multiple trucks from being at the same place and time on the track. The driving cycle was controlled with two radars (Figure 1). 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 of the track. Drivers received instructions by two-way radio, to ensure that the speed of the vehicles and the distance between the vehicles on the track remained constant. The duration of the runs was also checked. The vehicles were also instrumented with global positioning system (GPS) units, which were used for checking vehicle speed and distance.

Emissions measurement procedure

Dynacert requested emissions measurements, which were performed on the test tractor C6 (2243) using the Horiba OBS-2200 portable emission measuring system (Figure 5), based on CFR (Code of Federal Regulation), Title 40 Part 1065, Engine Testing Procedures, Part 1065 - Subpart J PEMS Testing (CFR 2008).

The emission measurements were performed on the ALPHA low-speed test track. The length of a test run was six laps (41.3 km), with departure and arrival at the same position along the track.

The tests can be characterized by the following:

- Two test segments: baseline segment (the test vehicle was not using the HydraGen™ technology) followed by a final test segment (the test vehicle using the HydraGen™ technology).
- Each test segment consisted of one warm-up run followed by three valid measurement runs;
- The runs were conducted at a constant speed of 80 km/h, with a standard acceleration and braking protocol;
- Standard emission test: measurement of carbon monoxide (CO), carbon dioxide (CO_2), mono-nitrogen oxides (NO_x), and total hydrocarbons (THC), in g/km.

For the purpose of the track emission tests, the test tractor was coupled with the Taylor RS-125K Towing Dynamometer for both baseline and final emission measurement tests, which assured controlled road load and also provided the electric power for the Horiba OBS-2200.

Figure 5. Test vehicle during track emissions measurement

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 DS 2424 A - 005, serial no. 76096; Calibration certificate NA6729-003-032817 from March 28, 2017.
- Calibrated scale with a capacity of 150 kg and a resolution of 0.02 kg: Ohaus 3000 serial no. 0015208-635; Calibration certificate NA6729-005-032817 from March 28, 2017.
- Vehicle scale: Moducam Bamd1117-5801L, serial no. 261102; Indicator: Rice-Lake; Calibration from April, 2017.
- Calibration weights TROEMNER 20 kg, serial no. FP-01, FP-02, FP-03, FP-04, FP-05, FP-06: Calibration certificate W-042658-24187 from March 20, 2017.
- Thermometer and hygrometer: Vaisala, model HMP-233, serial no. X0550005, range 0 - 100% RH; -40° to 60 °C; accuracy +/- 1%; +/- 0.1 °C; Calibration certificate 209692 from April 10, 2017.
- Wind monitor: Young model SE 09101, serial no. 118857, range 0-100 m/s; 0°-360°; accuracy ±0.3 m/s; ± 2°; Calibration certificate 209694 from April 20, 2017;
- Wind speed sensor: Campbell Scientific, model 014A, serial no. N5094, range 0-100 mph, accuracy 0.25 mph (0.40 km/h); Calibration certificate 209693 from April 20, 2017;
- Barometric pressure transducer: Omega, model PX2760-600A5V, serial no. 4892413, accuracy ± 0.25%; Calibration certificate 209691 from April 10, 2017;
- Data acquisition system: Fluke, model Hydra (2635A) Data Bucket, serial no. 5796307, accuracy ± 0.018%; Calibration certificate 209690 from April 10, 2017;
- Onboard computers: ISAAC DRU900, with GPS, speed precision 0.03 m/s.
- Horiba OBS-2200 portable emission measurement system: serial no. S2000594944000010, calibration before every measurement according to the *On Board Emission Measurement System OBS-2200 Instruction Manual* (Horiba 2011).
- Taylor RS-125K Towing Dynamometer, serial no.1P9CP4221EB343609, calibration before every measurement according to the *RS-90K - 200K Towing Dynamometer Operation & Maintenance Manual* (Taylor Dynamometer Inc. 2013).

Installation of HydraGen™ on test vehicle

The installation of HydraGen™ on the test vehicle C6 (2243) was done after the baseline test segment completed in the morning of June 6, 2017. The HydraGen™ device was installed on the test vehicle by, and under the supervision of Mr. Ruston Hoffman and Mr. Larry Amoh, the representatives of Dynacert.

Vehicle mileage at installation of the HydraGen™ was 154 277 km. After the installation of the device, the test vehicle accumulated break-in distance of 11 495 km, between June 7 and August 22, 2017, when the first test segment was completed, and of 24 181 km between June 7 and October 31, 2017, when the second test segment was completed. Figure 6 and Figure 7 present photos of the devices installed on the test vehicle.

Figure 6. Installation of HydraGen™ on test vehicle C6 (2243).

Figure 7. Gas injection port on air intake manifold on test vehicle C6 (2243).

Test results

Fuel consumption test results

The following results were obtained for HydraGen™from Dynacert:

- First test (see Table 2):
  - Fuel savings: 0.879 % ± 0.611 %
  - Fuel improvement: 0.887 % ± 0.616 %
- Second test (see Table 3):
  - Fuel savings: 5.530 % ± 1.009 %
  - Fuel improvement: 5.854 % ± 1.068 %
- These results were obtained at:
  - Trailer weight 20850 kg (45966 lb.), tractor weight 9010 kg (19864 lb.); Tractor-trailer gap[1]: 1422 mm (56 in.); aerodynamic gap[2]: 965 mm (38 in.);
  - Mean vehicle speed: 105 km/h (65 mph);
  - Mean air temperature:
    - First test 16.59 ± 5.48 °C (61.86 ± 9.86 °F);
    - Second test 9.78 ± 1.34 °C (49.6 ± 2.41 °F);
  - Mean wind speed:
    - First test 11.73 ± 1.90 km/h (7.29 ± 1.18 mph);
    - Second test 18.5 ± 4.88 km/h (11.5 ± 3.03 mph).

Tables 2 and 3 summarize the results and details of the baseline and test segments are presented in Appendix A. Appendix B presents data analysis.

The first test run of the first test segment (Table 2) was determined to be invalid because of heavy rain and pounding water on the test track. This test run is highlighted in yellow.

[1] Longitudinal distance between the vertical flat surface of the back of the cab/sleeper to the vertical flat surface on the front of the trailer (SAE International 2012).

[2] Longitudinal distance between the aft most point of the cab external surface, including aerodynamic side fairings, and the forward most point of the cargo-carrying portion of the vehicle (SAE International 2012).

Table 2. Summary of test results: first test

Baseline segment, June 6, 2017				*Test segment, August 22, 2017*			
Test runs	*Consumed fuel, kg*		*T / C ratio*	*Test runs*	*Consumed fuel, kg*		*T / C ratio*
	Test vehicle C6-T8 (2243-343)	*Control vehicle C7-T9 (2240-344)*			*Test vehicle C6-T8 (2243-343)*	*Control vehicle C7-T9 (2240-344)*	
1	36.30	34.96	1.0383	1	35.16	34.10	1.0311
2	36.52	35.18	1.0381	2	33.72	32.80	1.0280
3	36.74	35.52	1.0343	3	34.99	33.94	1.0309
				4	34.38	33.56	1.0244
Average T/C ratio			1.0369	**Average T/C ratio**			1.0278
Fuel savings, %				**0.879 ± 0.611**			
Fuel improvement, %				**0.887 ± 0.616**			

Table 3. Summary of test results: second test

Baseline segment, June 6, 2017				*Test segment, October 31, 2017*			
Test runs	*Consumed fuel, kg*		*T / C ratio*	*Test runs*	*Consumed fuel, kg*		*T / C ratio*
	Test vehicle C6-T8 (2243-343)	*Control vehicle C7-T9 (2240-344)*			*Test vehicle C6-T8 (2243-343)*	*Control vehicle C7-T9 (2240-344)*	
1	36.30	34.96	1.0383	1	35.32	35.98	0.9817
2	36.52	35.18	1.0381	2	35.34	35.90	0.9844
3	36.74	35.52	1.0343	3	34.88	35.86	0.9727
Average T/C ratio			1.0369	**Average T/C ratio**			0.9796
Fuel savings, %				**5.530 ± 1.009**			
Fuel improvement, %				**5.854 ± 1.068**			

Emissions measurement results

Table 4 presents the results of emissions measurement.

The results are showing significant decreases in emission levels between baseline and final measurements, of almost half for carbon monoxide (CO), total hydrocarbons (THC), and for mono-nitrogen oxides (NO_x).

There is not a noticeable difference between baseline and final measurement results for carbon dioxide (CO_2).

Table 4. Summary of emissions measurement results for test vehicle C6 (2243)

Test stage	***Baseline***				***Final***			
Date	June 7, 2017				August 23, 2017			
Test	1	2	3	**Average**	1	2	3	**Average**
Time	12:48:17	13:30:11	14:14:41	-	12:02:00	12:47:00	1:28:00	-
Emissions								
CO, g/km	1.200	0.461	0.643	**0.768**	0.123	0.482	0.623	**0.409**
CO_2, g/km	676.342	661.805	680.709	**672.952**	682.247	673.642	672.883	**676.257**
THC, g/km	0.009	0.012	0.014	**0.012**	0.009	0.003	0.007	**0.006**
NO_x, g/km	0.287	0.200	0.195	**0.227**	0.183	0.094	0.100	**0.126**
NO_x corr.,g/km	0.290	0.202	0.198	**0.230**	0.180	0.093	0.098	**0.124**
Average test conditions								
Distance (km)	41.36	41.36	41.37	**41.36**	41.44	41.35	41.36	**41.38**
Temperature, °C	23.22	23.91	24.42	**23.85**	19.04	19.55	20.06	**19.55**
Humidity, %	45.99	44.24	44.67	**44.97**	60.52	58.76	56.46	**58.58**
Pressure, mbar	1016.00	1016.00	1015.28	**1015.80**	1007.94	1007.96	1007.97	**1007.96**

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Discussion

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. It has been proven that the air density can be computed from measurements of ambient temperatures, humidity, barometric pressure, and wind speeds and directions (Surcel et al. 2008). These parameters were measured at the test site (Figure 8) and these data were verified using climate data from the Mirabel weather station, located 12 km from the test site (Environment Canada). Figure 9 presents the variation in air density during the testing. The maximum differences in air density between the baseline segment and the first and second test segments during the tests was 0.076 kg/m^3 (6.14% variation), and respectively 0.013 kg/m^3 (1.06% variation).

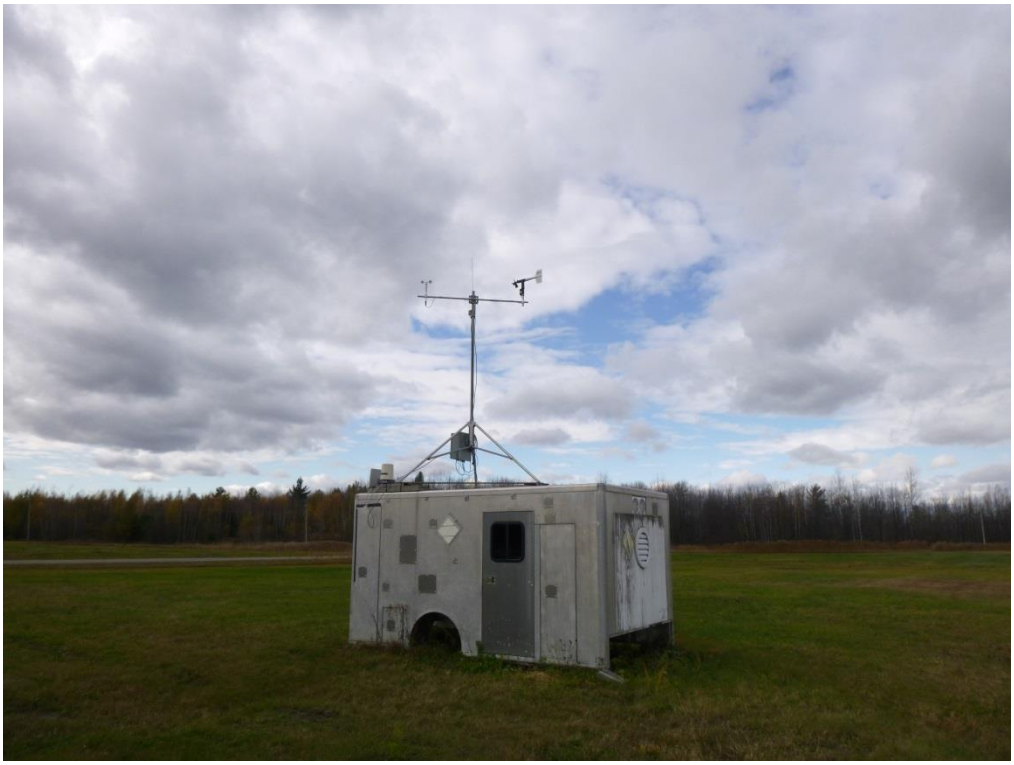

Figure 8. Measurement of environmental conditions at the test site.

The test results may also be higher or lower than average conditions depending on the wind velocity and direction, for aerodynamic device testing in particular. The elevation height for the wind measurement was 19.36 feet (5.90 m). The wind speed data was corrected to the elevation of 10 feet (3.05 m), using the scale factor of 0.9099. As shown in Appendix A and Figure 10, Figure 11 and Figure 12, the mean wind speed and the maximum wind gust speed observed during the tests were within the limit of 40.2 km/h (25 mph), and respectively 48.3 km/h (30 mph) (TMC 2016a.) However, using a closed-loop parabolic oval (shape of the test track) minimizes the effects of wind yaw angle.

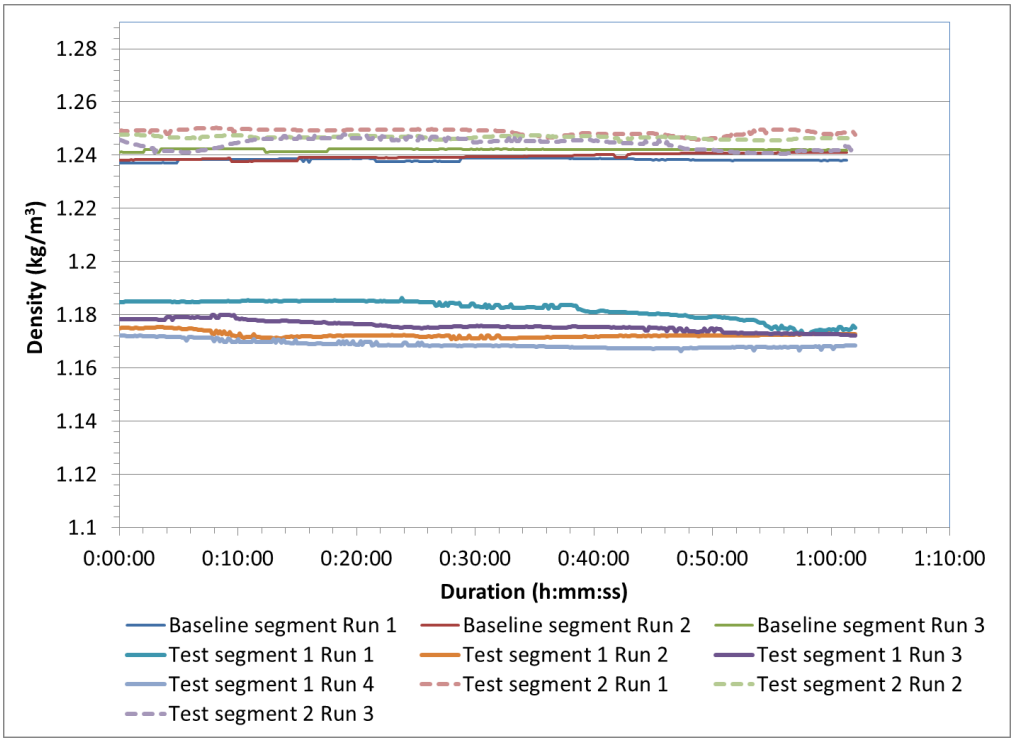

Figure 9. Air density variation during the tests.

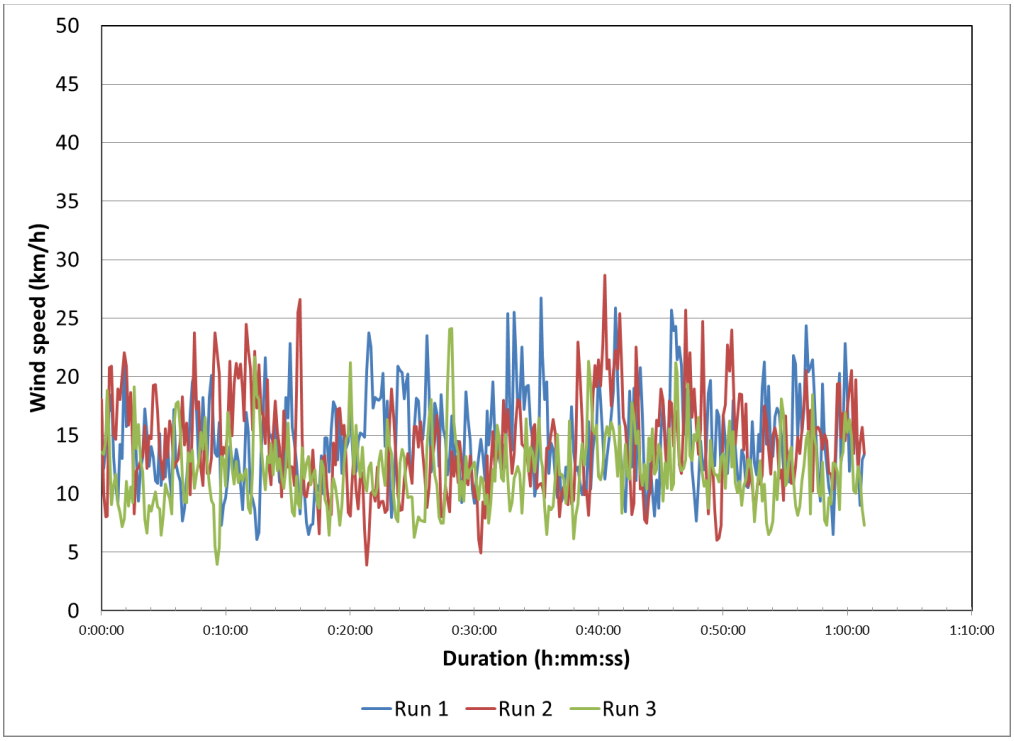

Figure 10. Wind speed variation during baseline segment.

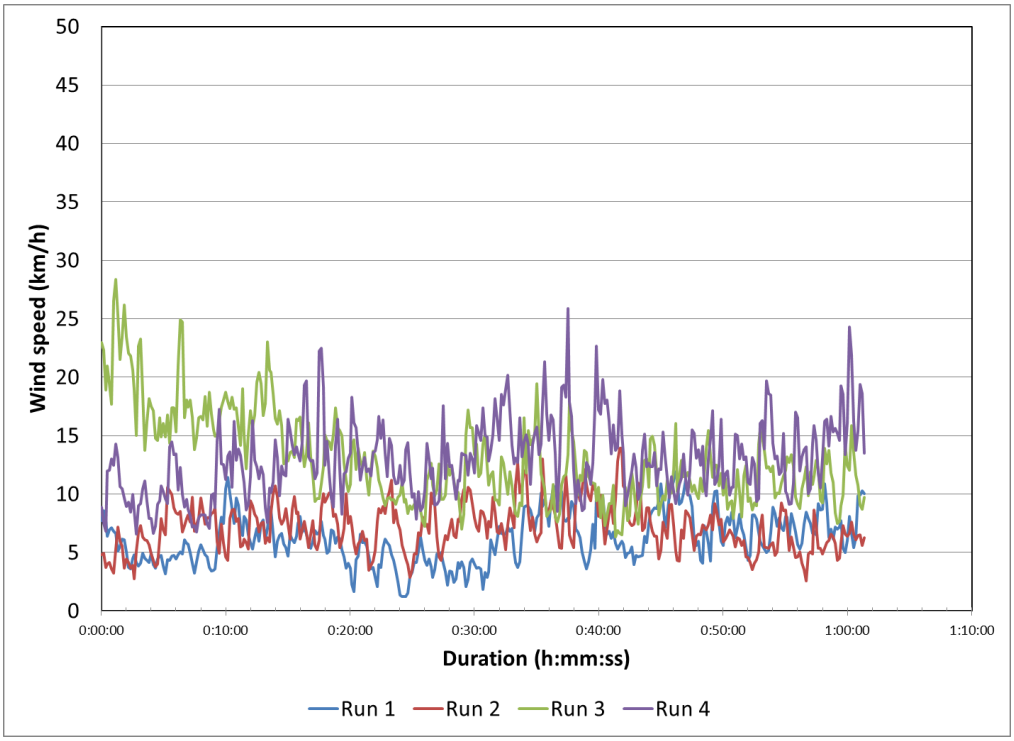

Figure 11. Wind speed variation during the first test segment.

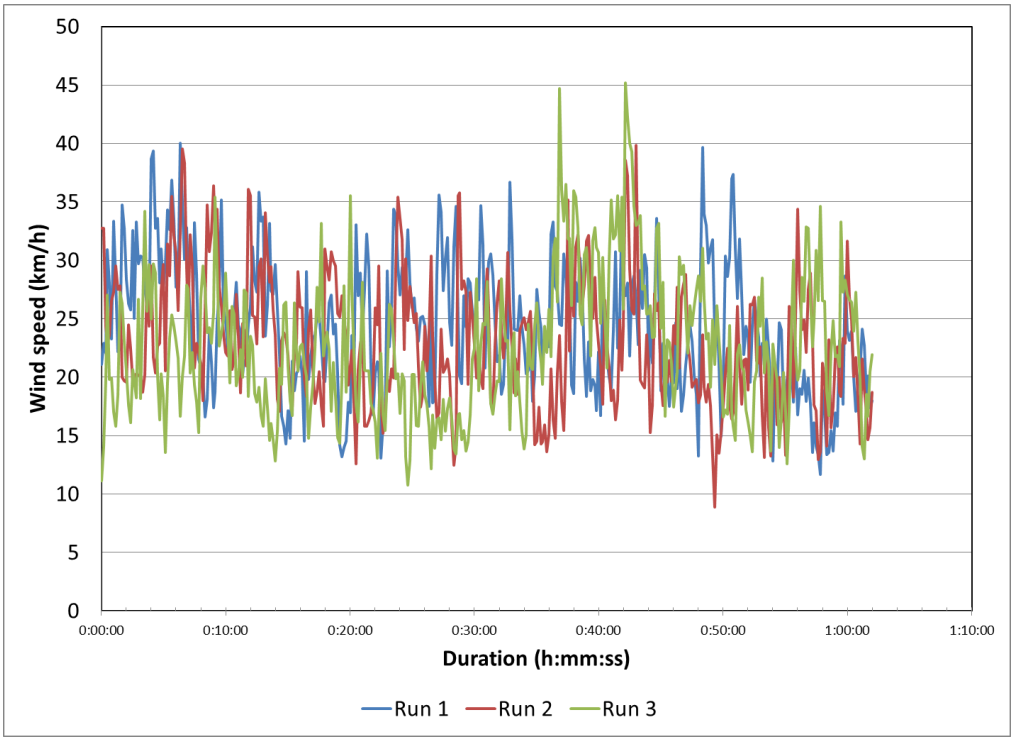

Figure 12. Wind speed variation during the second test segment.

The only possibility for minimizing the influence of varying ambient conditions on test results 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. The vehicles in a pair had similar odometer readings (i.e. at the beginning of test segment 153 973 km for the test tractor and 151 349 km for the control tractor).

The temperature of the fuel in the tank was randomly checked during the tests and never exceeded 48°C (118 °F); the maximum temperature value suggested by the practice is 71 °C (160 °F) (TMC 2016a). Fuel temperature was controlled given that the portable tanks used for fuel consumption measurements have a large capacity (144 liters, 38 US gallons), the test run duration was short (1 hour) and the return of the fuel into the tank is made by splashing.

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 checked against a known weight of 120 kg before each series of weighing (Figure 13). The portable scale was not moved between the initial and final weighing for a given test run.

Figure 13. Scale checking using a calibration weight set.

In order to eliminate the influences of traffic and variations in driver response, testing took place on a closed-loop test track at a fixed speed of 105 km/h (65 mph), with a standard acceleration and braking protocol for all drivers. In addition, travel speeds were monitored throughout the tests using radars, and drivers were instructed by radio if it became necessary to adjust their travel speed. Moreover, the vehicles were instrumented with GPS, and GPS data was used to confirm vehicle speed. The drivers' influence on the results was thus eliminated by strictly controlling the driving cycle.

Vehicle spacing was 0.8 km (0.5 mi.), which is within the limits stipulated by the practice (0.4 - 1.2 km, ¼ - 3/4 mi.)) (TMC 2016a).

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.

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Summary

Table 5 presents the fuel consumption test results obtained for the HydraGen™ technology from Dynacert, expressed for the confidence level of 95%[3].

Table 5. Summary of test results

Test segment	Test 1	Test 2
Test date	August 22, 2017	October 31, 2017
HydraGen™ brake-in mileage	11 495 km	24 181 km
Test results		
Fuel savings	0.879 % ± 0.611 %	5.530 % ± 1.009 %
Fuel improvement	0.887 % ± 0.616 %	5.854 % ± 1.068 %

Emission measurements are showing significant decreases in emission levels between baseline and final test segment measurements, of almost half for carbon monoxide (CO), total hydrocarbons (THC), and for mono-nitrogen oxides (NOx). Emissions of CO_2 where practically unchanged between baseline and final measurements.

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.

The representative of Dynacert observed the three segments of the tests performed on the product and validated the use of the HydraGen™technology on the test vehicle prior to the beginning of said tests. The representative of Dynacert also acknowledged that the tests he observed were conducted in conformity with the test protocol.

[3] To calculate fuel savings, the difference between the the baseline segment ratio and the test segment ratio is divided by the baseline segment ratio, whereas for the fuel improvement, the same difference is divided by the test segment ratio.

References

CFR (Code of Federal Regulation) (2008). *Title 40 Part 1065 Engine Testing Procedures. Part 1065 – Subpart J PEMS testing, §1065.901*.

Environment Canada (2017). *Climate data online*. Retrieved from: http://climate.weather.gc.ca/

Horiba (2011). *On Board Emission Measurement System OBS-2200 Instruction Manual*. Horiba Ltd., Kyoto, Japan.

Surcel, M.-D. (2017). *Fuel Consumption and Emissions Tests of the HydraGen™ Technology from Dynacert*. Contract Report 942-02. FPInnovations, Pointe-Claire, QC.

Surcel, M.-D., Michaelsen, J, Provencher, Y. (2008). *Track-test evaluation of aerodynamic drag reducing measures for Class 8 Tractor-Trailers*. Paper no. 2008-01-2600. SAE 2008 Commercial Vehicle Engineering Congress and Exhibition, October 7 –9, 2008, Rosemont – Chicago, IL.

Taylor Dynamometer Inc. (2013). *RS-90K - 200K Towing Dynamometer Operation & Maintenance Manual.* Taylor Dynamometer Inc., Milwaukee, WI.

Technology and Maintenance Council (TMC) (2016). *TMC Fuel Consumption Test Procedure Type II*, RP1102A. Technology and MaintenanceCouncil – American Trucking Association Inc. Arlington, VA.

Appendix A. Fuel consumption test segment data collection[4]

Baseline segment

SEGMENT DATA COLLECTION

Date: 6-Jun-17 **Segment:** BASELINE **Vehicle:** *Test Vehicle C6-T8 (2243-343)*

Testing Organization:	FPInnovations - PIT Group	**Test no.:**	4
Supplier:	Dynacert	**Test Site/Type:**	PMG Technologies / Track test
Technology:	HydraGen™	**Duty Cycle:**	Constant speed 105 km/h, 15 laps (100 km), Clockwise

Meteorological conditions:

Wind Data (km/h, at 3 m, 10 ft)						
Run	*Wind Dir.*	*Min Wind Speed*	*Max Wind Speed*	*Mean Wind Speed*	*Segment Mean Wind Speed Variation*	*Test Mean Wind Speed Variation*
1	55	6.10	26.76	14.61	2.61	9.75
2	57	3.91	28.65	14.27		
3	55	3.97	24.11	12.00		*Test Mean Wind Speed*
4						18.50
5						
Segment	56	3.91	28.65	13.63		

Run	*Temperature Data, (°C)*						*Other Data*			*Scale Check Weight*
	Min Temp.	*Max Temp.*	*Mean Temp.*	*Run Temp. Variation*	*Segment Temp. Variation*	*Test Temp. Variation*	*Mean Humidity (%)*	*Mean pressure (mbar)*	*Weather*	
1	11.26	11.49	11.36	0.23	0.50	2.67	94.73	1015.80	Light rain	YES-OK
2	10.82	11.47	11.14	0.65			92.77	1015.89	Light rain	YES-OK
3	10.79	10.94	10.86	0.15		*Test mean temperature*	92.54	1016.87	Light rain	YES-OK
4										
5						9.78				
Segment	10.79	11.49	11.12	S/O			93.35	1016.19	S/O	S/O

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Vehicle Time	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*
1	12	8:09:00	153973	125.58	9:07:04	154075	89.28	0:58:04	102.0	36.30
2	22	9:18:10	154075	129.64	10:16:16	154176.0	93.12	0:58:06	101.0	36.52
3	71	10:27:40	154176.0	96.54	11:25:43	154277.0	59.80	0:58:03	101.0	36.74
4										
5										
								Autofill after each row		

Notes:
1. Run Time for each vehicle must be within 0.25% of a vehicle's Segment Run #1 Time.
2. All wind speed and wind temperature constraints must be satisfied.
3. No equipment failure or malfunction or drive error.
4. If the three criteria above are not satisfied the Run must be repeated.

Observer	***Jean***	***Driver***	***André***
Prepared by		***Marius-Dorin Surcel, Eng. (135765)***	

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

SEGMENT DATA COLLECTION

Date: 6-Jun-17 **Segment:** BASELINE **Vehicle:** *Control Vehicle C7-T9 (2240-344)*

Testing Organization:	FPInnovations - PIT Group	**Test no.:**	4
Supplier:	Dynacert	**Test Site/Type:**	PMG Technologies / Track test
Technology:	HydraGen™	**Duty Cycle:**	Constant speed 105 km/h, 15 laps (100 km), Clockwise

Meteorological conditions:

Wind Data (km/h, at 3 m, 10 ft)						
Run	*Wind Dir.*	*Min Wind Speed*	*Max Wind Speed*	*Mean Wind Speed*	*Segment Mean Wind Speed Variation*	*Test Mean Wind Speed Variation*
1	55.26	6.10	26.76	14.61	2.61	9.75
2	57.13	3.91	28.65	14.27		
3	55.48	3.97	24.11	12.00		*Test Mean Wind Speed*
4						18.50
5						
Segment	S/O	3.91	28.65	13.63		

Run	*Temperature Data, (°C)*						*Other Data*			*Scale Check Weight*
	Min Temp.	*Max Temp.*	*Mean Temp.*	*Run Temp. Variation*	*Segment Temp. Variation*	*Test Temp. Variation*	*Mean Humidity (%)*	*Mean pressure (mbar)*	*Weather*	
1	11.26	11.49	11.36	0.23	0.5	2.67	94.73	1015.80	Light rain	YES-OK
2	10.82	11.47	11.14	0.65			92.77	1015.89	Light rain	YES-OK
3	10.79	10.94	10.86	0.15		*Test mean temperature*	92.54	1016.87	Light rain	YES-OK
4										
5						9.78				
Segment	10.79	11.49	11.12	S/O			93.35	1016.19	S/O	S/O

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Vehicle Time	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*
1	54	8:09:50	151349.0	125.20	9:07:52	151450.0	90.24	0:58:02	101.0	34.96
2	110	9:19:00	151450.0	129.56	10:17:06	151552.0	94.38	0:58:06	102.0	35.18
3	2	10:28:30	151552.0	101.26	11:26:37	151653.0	65.74	0:58:07	101.0	35.52
4										
5										
								Autofill after each row		

Notes:
1. Run Time for each vehicle must be within 0.25% of a vehicle's Segment Run #1 Time.
2. All wind speed and wind temperature constraints must be satisfied.
3. No equipment failure or malfunction or drive error.
4. If the three criteria above are not satisfied the Run must be repeated.

Observer	***Jean***	***Driver***	***Guy***
Prepared by		***Marius-Dorin Surcel, Eng. (135765)***	

Test segment 1

SEGMENT DATA COLLECTION

Date: 22-Aug-17 **Segment:** TEST **Vehicle:** *Test Vehicle C6-T8 (2243-343)*

Testing Organization:	FPInnovations - PIT Group		**Test no.:** 4
Supplier:	Dynacert	**Test Site/Type:**	PMG Technologies / Track test
Technology:	HydraGen™	**Duty Cycle:**	Constant speed 105 km/h, 15 laps (100 km), Clockwise

Meteorological conditions:

Wind Data (km/h, at 3 m, 10 ft)						
Run	*Wind Dir.*	*Min Wind Speed*	*Max Wind Speed*	*Mean Wind Speed*	*Segment Mean Wind Speed Variation*	*Test Mean Wind Speed Variation*
1	114	1.21	11.94	6.21	6.80	3.79
2	137	2.58	13.92	7.18		
3	221	6.31	28.34	13.01		*Test Mean Wind Speed*
4	199	6.55	25.86	12.95		11.73
5						
Segment	S/O	1.21	28.34	9.84		

Run	*Temperature Data, (°C)*						*Other Data*			*Scale Check Weight*
	Min Temp.	*Max Temp.*	*Mean Temp.*	*Run Temp. Variation*	*Segment Temp. Variation*	*Test Temp. Variation*	*Mean Humidity (%)*	*Mean pressure (mbar)*	*Weather*	
1	20.55	22.82	21.12	2.27	1.72	10.95	96.71	1007.40	Heavy rain	YES-OK
2	22.27	22.93	22.61	0.66			92.16	1004.61	Light rain, cloudy	YES-OK
3	20.83	22.31	21.69	1.48		*Test mean temperature*	90.61	1003.73	Cloudy	YES-OK
4	22.34	23.15	22.84	0.81			89.02	1002.18	Cloudy	YES-OK
5						16.59				
Segment	20.55	23.15	22.07	S/O			92.13	1004.48	S/O	S/O

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Vehicle Time	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*
1	7	12:28:00	165772.0	129.72	13:26:05	165873.0	94.56	0:58:05	101.0	35.16
2	57	13:51:00	165873.0	74.26	14:49:03	165975.0	40.54	0:58:03	102.0	33.72
3	46	15:26:30	165975.0	93.98	16:24:34	166077.0	58.99	0:58:04	102.0	34.99
4	5	16:35:00	166067.0	127.84	17:33:02	166179.0	93.46	0:58:02	112.0	34.38
5										

Autofill after each row

Notes:
1. Run Time for each vehicle must be within 0.25% of a vehicle's Segment Run #1 Time.
2. All wind speed and wind temperature constraints must be satisfied.
3. No equipment failure or malfunction or drive error.
4. If the three criteria above are not satisfied the Run must be repeated.

Observer	***Jean***	***Driver***	***André***
Prepared by		***Marius-Dorin Surcel, Eng. (135765)***	

SEGMENT DATA COLLECTION

Date: 22-Aug-17 **Segment:** TEST **Vehicle:** *Control Vehicle C7-T9 (2240-344)*

Testing Organization:	FPInnovations - PIT Group		**Test no.:** 4
Supplier:	Dynacert	**Test Site/Type:**	PMG Technologies / Track test
Technology:	HydraGen™	**Duty Cycle:**	Constant speed 105 km/h, 15 laps (100 km), Clockwise

Meteorological conditions:

Wind Data (km/h, at 3 m, 10 ft)						
Run	*Wind Dir.*	*Min Wind Speed*	*Max Wind Speed*	*Mean Wind Speed*	*Segment Mean Wind Speed Variation*	*Test Mean Wind Speed Variation*
1	114	1.21	11.94	6.21	6.80	3.79
2	137	2.58	13.92	7.18		
3	221	6.31	28.34	13.01		*Test Mean Wind Speed*
4	199	6.55	25.86	12.95		11.73
5						
Segment	S/O	1.21	28.34	9.84		

Run	*Temperature Data, (°C)*						*Other Data*			*Scale Check Weight*
	Min Temp.	*Max Temp.*	*Mean Temp.*	*Run Temp. Variation*	*Segment Temp. Variation*	*Test Temp. Variation*	*Mean Humidity (%)*	*Mean pressure (mbar)*	*Weather*	
1	20.55	22.82	21.12	2.27	1.72	10.95	96.71	1007.40	Heavy rain	YES-OK
2	22.27	22.93	22.61	0.66			92.16	1004.61	Light rain, cloudy	YES-OK
3	20.83	22.31	21.69	1.48		*Test mean temperature*	90.61	1003.73	Cloudy	YES-OK
4	22.34	23.15	22.84	0.81			89.02	1002.18	Cloudy	YES-OK
5						16.59				
Segment	20.55	23.15	22.07	S/O			92.13	1004.48	S/O	S/O

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Vehicle Time	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*
1	46	12:30:00	158242.0	128.08	13:28:03	158344.0	93.98	0:58:03	102.0	34.10
2	14	13:53:00	158344.0	77.92	14:51:05	158446.0	45.12	0:58:05	102.0	32.80
3	7	15:28:30	158446.0	94.56	16:26:35	158548.0	60.62	0:58:05	102.0	33.94
4	6	16:37:00	158548.0	126.64	17:35:06	158650.0	93.08	0:58:06	102.0	33.56
5										
								Autofill after each row		

Notes:
1. Run Time for each vehicle must be within 0.25% of a vehicle's Segment Run #1 Time.
2. All wind speed and wind temperature constraints must be satisfied.
3. No equipment failure or malfunction or drive error.
4. If the three criteria above are not satisfied the Run must be repeated.

Observer	***Jean***	***Driver***	***Guy***
Prepared by		***Marius-Dorin Surcel, Eng. (135765)***	

Test segment 2

SEGMENT DATA COLLECTION

Date: 31-Oct-17 **Segment:** TEST **Vehicle:** *Test Vehicle C6-T8 (2243-343)*

Testing Organization:	FPInnovations - PIT Group		**Test no.:** 4
Supplier:	Dynacert	**Test Site/Type:**	PMG Technologies / Track test
Technology:	HydraGen™	**Duty Cycle:**	Constant speed 105 km/h, 15 laps (100 km), Clockwise

Meteorological conditions:

Wind Data (km/h, at 3 m, 10 ft)						
Run	*Wind Dir.*	*Min Wind Speed*	*Max Wind Speed*	*Mean Wind Speed*	*Segment Mean Wind Speed Variation*	*Test Mean Wind Speed Variation*
1	239.72	11.70	40.00	24.38	1.66	9.75
2	249.20	8.88	39.83	23.03		
3	245.92	10.76	45.20	22.72		*Test Mean Wind Speed*
4						18.50
5						
Segment	244.95	8.88	45.20	23.38		

Run	*Temperature Data, (°C)*						*Other Data*			*Scale Check Weight*
	Min Temp.	*Max Temp.*	*Mean Temp.*	*Run Temp. Variation*	*Segment Temp. Variation*	*Test Temp. Variation*	*Mean Humidity (%)*	*Mean pressure (mbar)*	*Weather*	
1	7.39	8.36	7.77	0.97	1.32	2.67	61.08	1009.13	Mostly cloudy	YES-OK
2	8.23	8.74	8.48	0.51			57.40	1009.98	Mostly cloudy	YES-OK
3	8.52	9.88	9.09	1.36		*Test mean temperature*	55.15	1010.17	Mostly cloudy	YES-OK
4										
5						9.78				
Segment	7.39	9.88	8.45	S/O			57.88	1009.76	S/O	S/O

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Vehicle Time	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*
1	57	10:45:00	178458.0	129.02	11:43:01	178559.0	93.70	0:58:01	101.0	35.32
2	7	12:07:00	178559.0	95.74	13:05:03	178661.0	60.40	0:58:03	102.0	35.34
3	57	13:15:00	178661.0	93.70	14:13:04	178763.0	58.82	0:58:04	102.0	34.88
4										
5										
								Autofill after each row		

Notes:
1. Run Time for each vehicle must be within 0.25% of a vehicle's Segment Run #1 Time.
2. All wind speed and wind temperature constraints must be satisfied.
3. No equipment failure or malfunction or drive error.
4. If the three criteria above are not satisfied the Run must be repeated.

Observer	***Steve***	***Driver***	***André***
Prepared by		***Marius-Dorin Surcel, Eng. (135765)***	

SEGMENT DATA COLLECTION

Date: 31-Oct-17 **Segment:** TEST **Vehicle:** *Control Vehicle C7-T9 (2240-344)*

Testing Organization:	FPInnovations - PIT Group	**Test no.:**	4
Supplier:	Dynacert	**Test Site/Type:**	PMG Technologies / Track test
Technology:	HydraGen™	**Duty Cycle:**	Constant speed 105 km/h, 15 laps (100 km), Clockwise

Meteorological conditions:

Wind Data (km/h, at 3 m, 10 ft)						
Run	*Wind Dir.*	*Min Wind Speed*	*Max Wind Speed*	*Mean Wind Speed*	*Segment Mean Wind Speed Variation*	*Test Mean Wind Speed Variation*
1	239.72	11.70	40.00	24.38	1.66	9.75
2	249.2	8.88	39.83	23.03		
3	245.92	10.76	45.20	22.72		*Test Mean Wind Speed*
4						18.50
5						
Segment	S/O	8.88	45.20	23.38		

Run	*Temperature Data, (°C)*						*Other Data*			*Scale Check Weight*
	Min Temp.	*Max Temp.*	*Mean Temp.*	*Run Temp. Variation*	*Segment Temp. Variation*	*Test Temp. Variation*	*Mean Humidity (%)*	*Mean pressure (mbar)*	*Weather*	
1	7.39	8.36	7.77	0.97	1.32	2.67	61.08	1009.13	Mostly cloudy	YES-OK
2	8.23	8.74	8.48	0.51			57.40	1009.98	Mostly cloudy	YES-OK
3	8.52	9.88	9.09	1.36		*Test mean temperature*	55.15	1010.17	Mostly cloudy	YES-OK
4										
5						9.78				
Segment	7.39	9.88	8.45	S/O			57.88	1009.76	S/O	S/O

Test Runs Details:

Run	*Tank ID*	*Start*			*Finish*			*Difference*		
		Vehicle Time	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*	*Vehicle Time*	*Odometer (km)*	*Fuel tank weight (kg)*
1	5	10:47:00	163319.0	123.02	11:45:04	163420.0	87.04	0:58:04	101.0	35.98
2	6	12:09:00	163420.0	90.52	13:07:05	163522.0	54.62	0:58:05	102.0	35.90
3	5	13:17:00	163522.0	87.04	14:15:02	163623.0	51.18	0:58:02	101.0	35.86
4										
5										
								Autofill after each row		

Notes:
1. Run Time for each vehicle must be within 0.25% of a vehicle's Segment Run #1 Time.
2. All wind speed and wind temperature constraints must be satisfied.
3. No equipment failure or malfunction or drive error.
4. If the three criteria above are not satisfied the Run must be repeated.

Observer	***Steve***	***Driver***	***Guy***
Prepared by		***Marius-Dorin Surcel, Eng. (135765)***	

Appendix B. Fuel consumption test data analysis

Test 1

RESULTS DATA ANALYSIS

PIT Group FPInnovations

Testing Organization:	FPInnovations - PIT Group			**Test no.:**	4
Supplier:	Dynacert		**Test Site/Type:**	**PMG Technologies / Track test**	
Technology:	HydraGen™		**Duty Cycle:**	**Constant speed 105 km/h, 15 laps (1**	

Baseline Segment	**Date:**		**6-Jun-17**
Consumed fuel (kg)			
Run	Test C6-T8 (2243-343)	Control C7-T9 (2240-344)	T/C
1	36.30	34.96	1.0383
2	36.52	35.18	1.0381
3	36.74	35.52	1.0343
4			
5			
6			

Test Segment	**Date:**		**22-Aug-17**
Consumed fuel (kg)			
Run	Test C6-T8 (2243-343)	Control C7-T9 (2240-344)	T/C
1	35.16	34.10	1.0311
2	33.72	32.80	1.0280
3	34.99	33.94	1.0309
4	34.38	33.56	1.0244
5			
6			

Summary Stats		
	Baseline	Final
Mean T/C	1.0369	1.0278
Number of Data Points	3	3
Standard Deviations	0.0022	0.0033
Variances	0.000005	0.000011
Difference in Means	0.0091	

F-Test for Equal Variances	
Baseline T/C Variance	0.00000
Test T/C Variance	0.00001
F test stat (test/baseline)	2.12835
F low	0.02564
F high	39.00000
Are Variances Equal ?	**YES**

T-Test with Equal Variances (2-tailed)	
Pooled St dev	0.00279
t-crit	2.776
t-stat	3.997
Is Fuel Economy Improved ?	**YES**
P-value	0.0161728
lower CI bound	0.00278
upper CI bound	0.01545

T-Test with Unequal Variances (2-tailed)	
df (nu)	3.540
t-crit	2.925
t-stat	3.997
Is Fuel Economy Improved ?	**YES**
P-value	0.0205
lower CI bound	0.00244
upper CI bound	0.01579

Test Result			
	Nominal	Confidence Interval	
Fuel Savings	**0.879%**	±	**0.611%**
Fuel Improvement	**0.887%**	±	**0.616%**

CI t-critical	2.776
CI std err term	0.00228

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

Test 2

RESULTS DATA ANALYSIS

PIT Group FPInnovations

Testing Organization:	FPInnovations - PIT Group			**Test no.:**	**4**
Supplier:	Dynacert		**Test Site/Type:**	**PMG Technologies / Track test**	
Technology:	HydraGen™		**Duty Cycle:**	**Constant speed 105 km/h, 15 laps (1**	

Baseline Segment	**Date:**	**6-Jun-17**
Consumed fuel (kg)		
Run	Test C6-T8 (2243-343)	Control C7-T9 (2240-344)	T/C
1	36.30	34.96	1.0383
2	36.52	35.18	1.0381
3	36.74	35.52	1.0343
4			
5			
6			

Final Segment	**Date:**	**31-Oct-17**
Consumed fuel (kg)		
Run	Test C6-T8 (2243-343)	Control C7-T9 (2240-344)	T/C
1	35.32	35.98	0.9817
2	35.34	35.90	0.9844
3	34.88	35.86	0.9727
4			
5			
6			

Summary Stats		
	Baseline	Final
Mean T/C	1.0369	0.9796
Number of Data Points	3	3
Standard Deviations	0.0022	0.0061
Variances	0.000005	0.000038
Difference in Means	0.0573	

F-Test for Equal Variances	
Baseline T/C Variance	0.00000
Test T/C Variance	0.00004
F test stat (test/baseline)	7.54608
F low	0.02564
F high	39.00000
Are Variances Equal ?	**YES**

T-Test with Equal Variances (2-tailed)	
Pooled St dev	0.00462
t-crit	2.776
t-stat	15.213
Is Fuel Economy Improved ?	**YES**
P-value	0.0001089
lower CI bound	0.04688
upper CI bound	0.06781

T-Test with Unequal Variances (2-tailed)	
df (nu)	2.521
t-crit	3.554
t-stat	15.213
Is Fuel Economy Improved ?	**YES**
P-value	0.0015
lower CI bound	0.04395
upper CI bound	0.07074

Test Result			
	Nominal	Confidence Interval	
Fuel Savings	**5.530%**	**±**	**1.009%**
Fuel Improvement	**5.854%**	**±**	**1.068%**

CI t-critical	2.776
CI std err term	0.00377

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

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For more information:

Marius-Dorin Surcel, Eng., M.A.Sc.

Principal Scientist

570, boul. Saint-Jean, Pointe-Claire (QC) H9R 3J9

☎ 514 782-4519

marius.surcel@fpinnovations.ca
www.pit.fpinnovations.ca
www.fpinnovations.ca

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