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PIT Group
By FPInnovations

Contract Report RC-911-08:

Fuel Consumption Test for the Evaluation of the IceCOLD® Product from EcoCOOL World, LLC

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Bernard Ouellet, PIT Group Operations Leader

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Contract Report 911-08:

Fuel Consumption Test for the Evaluation of the IceCOLD® Product from EcoCOOL World, LLC

Prepared by:

Adime Kofi Bonsi, Eng., M.Eng. (5019987)

Verified by:

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

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Summary

EcoCOOL World, LLC mandated FPInnovations to conduct testing to evaluate the impact of the IceCOLD® product on the fuel consumption of a refrigeration unit installed on a 48-ft refrigerated van semitrailer.

The tests were conducted at the Transport Canada Motor Vehicle Test Centre in Blainville, Quebec, which is presently operated by PMG Technologies, in an environmental chamber at an ambient temperature of +30°C. The refrigerated box was maintained at an interior temperature of -10°C. Fuel consumption tests are conducted to compare the fuel consumption of the same refrigeration unit installed on the same test vehicle (48-ft refrigerated van semitrailer) in two different conditions:

- The refrigeration unit with no technology installed (Baseline segment); and
- The refrigeration unit with the IceCOLD® product installed (Final segment).

Results of the fuel consumption tests performed on the IceCOLD® product installed on the refrigeration unit showed fuel savings of 14.30%, which could lead to a reduction in greenhouse gas (GHG) emissions of 2.60 tonnes per vehicle each year.

The IceCOLD® product could yield additional benefits during normal vehicle operation, based on its ability to accelerate cooling, which could translate into greater long-term fuel savings for a fleet implementing this product.

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Introduction

Context

The ministère des Transports du Québec (MTQ) established the Écocamionnage assistance program to reduce GHG emissions in road freight transportation. This program is part of the implementation of the Government of Quebec's 2013-2020 Action Plan on Climate Change, Priority 17, with the theme: "Reducing the environmental footprint of road freight transport".

The Écocamionnage program aims at evaluating the reduction of fuel consumption and the impact on GHG emissions of green technologies such as the IceCOLD® product (hereafter IceCOLD). If the technology evaluated meets the objectives of the program, it will be added to the list of products eligible for a purchase grant.

As a third-party technology testing organization, FPInnovations' PIT Group conducted tests on IceCOLD to measure its impact on the fuel consumption of a refrigeration unit (reefer) installed on a 48-ft refrigerated van semitrailer (trailer).

Description of the Technology

Description

IceCOLD is an engineered synthetic formula, designed specifically to improve operational performance of refrigeration and air conditioning systems. It was discovered by the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHREA). IceCOLD acts as a catalyst to reduce oil fouling, thereby making the heat exchange process more efficient. Oil fouling is a significant factor in bottom line energy costs for a full spectrum of business and industry, including government buildings, school, hospitals, business and residential homes (IceCOLD 2015).

Target Applications

According to the technology supplier, IceCOLD delivers significant and measurable fuel/KWh savings and/or valuable processing benefits through reduced cooling times, and cost savings can be achieved across the refrigerated products supply chain, including pre-cooling, storage, transportation and retail.

Technological Advancement

According to the technology supplier, IceCOLD is installed once and lasts for the life of the system. It is described as a non-toxic, non-hazardous, 'green' technology which reduces energy consumption. The Primary Catalyst improves efficiency of heat exchange by removing oil fouling, while the Secondary Catalyst causes refrigerant to evaporate at a lower temperature and creates cooler air flow from the supply air outlet. This enables the system to reach the temperature set-point faster, decreasing equipment run time.

According to the technology supplier, IceCOLD also contains an Advanced Lubricant Agent, which mixes with existing compressor oils and improves lubricity by 54% based on SAE test results. These efficiency improvements create large fuel/KWh savings or valuable reductions in product processing times.

Product Installation

IceCOLD is commonly installed at 10% IceCOLD to the total oil charge to the reefer compressor low pressure service port, and not to the refer diesel engine. It is recommended that an equal amount of compressor oil be removed from the reefer prior to adding IceCOLD. The amount of product required for various sizes of trailer units is presented in Table 1.

Table 1. Amount of IceCOLD required for various vehicle types

Refrigerated Vehicle	Amount of IceCOLD Required
1.5 ton box truck with reefer compressor driven by the truck's engine	5 ounces
1.5 ton box truck with its own separate reefer engine	8 ounces
2.5 ton reefer trailer	8 ounces
5 ton reefer trailer	12 ounces
Rail road car reefer	16 ounces

After installation, the product must be given enough time to react in order to produce expected results. The reefer should run 40 to 100 or more compressor hours after IceCOLD is installed for the product to fully react. Figure 1 shows the IceCOLD product prior to installation.

Figure 1. IceCOLD prior to installation

After the Baseline segment, the technology supplier installed the product (as shown in Figure 2), on September 16, 2015. They removed an amount of compressor oil from the reefer and added 12 ounces of IceCOLD through the low pressure service port of the reefer. The test vehicle was then sent into operation and allowed to run for a break-in period of at least 80 hours to allow the reaction to take place. This break-in period and all related activities were managed by the technology supplier and a third-party fleet, and were not under the operational control of FPInnovations.

Figure 2. Installation of IceCOLD

Test Description

Test Site

The tests were conducted in an environmental chamber under controlled conditions (temperature and humidity) at the Transport Canada Motor Vehicle Test Centre in Blainville, Quebec, which is presently operated by PMG Technologies.

The chamber is 16.5 m long and 6.10 m wide. Its access door is 3.35 m wide and 4.14 m high. Table 2 presents the environmental chamber's specifications. Figure 3 shows the refrigerated trailer and refrigeration unit in the environmental chamber prior to conditioning.

Table 2. Characteristics of the environmental chamber

Temperature range	-55°C to +80°C
Humidity range	8% to 95%
Cooling capacity	130 kW at -40°C; 444 000 BTU/h
Cooling rate	20°C/h
Heating rate	15°C/h
Air evacuation rate	56 m^3/min
Air intake	90.6 m^3/min

Figure 3. Refrigerated trailer and refrigeration unit in the environmental chamber

Test Methodology

The tests were conducted at an ambient temperature of +30°C. The interior temperature of the trailer was kept at -10°C. The ambient temperature and humidity of the environmental chamber, as well as the trailer interior temperature were recorded every 10 seconds. Figure 4 shows the screen used for real time monitoring of these measurements.

Fuel consumption tests were conducted to compare the fuel consumption of the same reefer installed on the same trailer in two different conditions:

- The reefer with no technology installed (Baseline segment); and
- The reefer unit with IceCOLD installed (Final segment).

For the two segments (Baseline and Final), the trailer was empty, since a reefer consumes more fuel to keep the temperature of an empty trailer cool compared to one that contains products. Note that refrigerated products are always already cold when loaded into a trailer and act as a thermal mass. Thus, the test situation represents an extreme case of cooling and, therefore, of energy use.

Figure 4. Real-time monitoring of environmental chamber and trailer interior conditions

Conditioning

Before each test segment, the test vehicle was prepared for the test as follows:

- The trailer (with rear door open) was soaked for at least 8 hours in the environmental chamber with ambient temperature of +30°C;
- The reefer was connected to a portable fuel tank. Figure 5 shows the installation of the portable fuel tank and the scale used for this test;
- The trailer door was then closed and the reefer was programmed to reach the interior temperature set point of -10°C. Figure 6 shows the temperature control for the refrigeration unit.
- Once the interior temperature dropped to -10°C, the refrigeration unit was turned off, the trailer door was opened for 10 minutes (to simulate a delivery operation);
- The portable tank was weighed on the scale shown in Figure 5, and its weight was recorded as the initial weight for the first test run.

Baseline and Final Test Runs

The test runs were identical for both the Baseline and Final segments. When the required interior temperature of the trailer was reached after conditioning, three test runs were conducted to measure the fuel consumed by the reefer in order to keep the trailer's interior temperature at the set point -10°C as follows:

- Each test run lasted three hours;
- The test runs were separated by 10-minute stops, during which the reefer was turned off and the rear door of the trailer was opened to simulate a delivery operation;
- During the stops, the portable tank was weighed and the weights were recorded and used for fuel savings calculations.

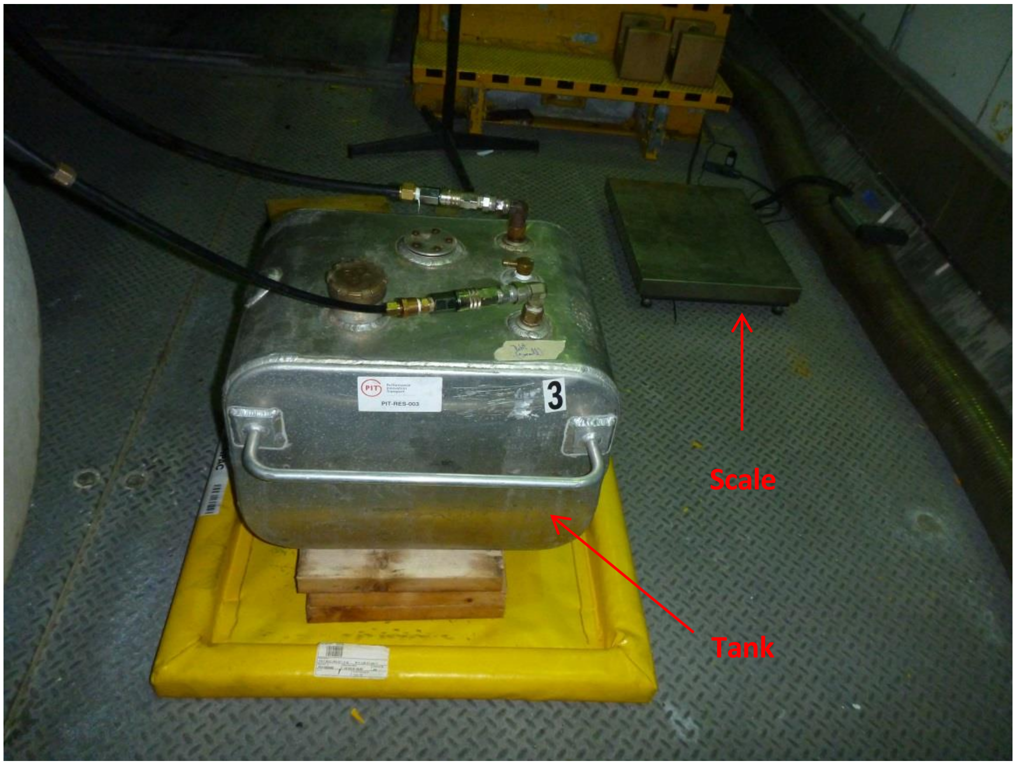

Figure 5. Installation of the portable fuel tank

Figure 6. Temperature control for the refrigeration unit

Data Analysis

The fuel consumption of the reefer was measured by comparing the weight of a portable fuel tank before and after each test run. The trailer and the reefer were in good working condition. The result of a test segment is the average fuel consumed during the three runs. The result of the test is the variation in percent between the total fuel consumed in the Baseline and Final test segment.

The ratio of the fuel consumed by the refrigeration unit during the Baseline segment and the Final segment (B/F) was calculated for the pairs of tests corresponding to the two segments, to ensure that the results were repetitive, similar to SAE standards (SAE International 2012) and (SAE International 1987).

For each pair of tests, the fuel saved (E_{Ci}) was expressed as the variation in percentage between the quantities of fuel consumed in the respective runs of the Baseline segment (B_i) and Final segment (F_i), using the equation:

$$E_{Ci} = 100 \times \frac{B_i - F_i}{B_i} \tag{1}$$

Subsequently, the fuel consumed by the reefer during the three runs for each test segment was summed up: $\sum_{i=1}^{3} B_i$ for the Baseline segment (no technology installed) and $\sum_{i=1}^{3} F_i$ for the Final test segment (IceCold installed in reefer). The representative result of the test is the fuel saved expressed in the variation in percent between the total fuel consumed in the Baseline and Final test segments, E_C, calculated with the following equation:

$$E_C = 100 \times \frac{\sum_{i=1}^{3} B_i - \sum_{i=1}^{3} F_i}{\sum_{i=1}^{3} B_i} \tag{2}$$

Test Vehicle –Trailer

The test vehicle used for both the Baseline and Final test segments was a Great Dane refrigerated trailer. The vehicle characteristics are presented in Table 3. Figure 7 and Figure 8 show the exterior and interior of the trailer used for this test, respectively.

Table 3. Characteristics of the refrigerated trailer

Test Segment	Baseline and Final
VIN	1GRAA96275W706052
Make and model	Great Dane 7811TZ-1APЖ48
Year	2005
Length	48 ft.
Tires	Bridgestone 11R22.2

Figure 7. Exterior of the test trailer

Figure 8. Interior of the test trailer

Refrigeration Unit

The reefer used for both the Baseline and Final test segments was a Thermo King Spectrum DE, as shown in Figure 9. The characteristics for this reefer are presented in Table 4.

Figure 9. Refrigeration unit

Table 4. Characteristics of the refrigeration unit

Serial number	01566X5040
Make and model	Thermo King Spectrum DE 30-3
Year	2003
Engine make and model	Yanmar TK486E 4TNE86-ETK
Engine family	3YDXL2.09D4N
Number of cylinders	4
Displacement	2.091 L
Compressor	Thermo King 5D37286
Refrigerant	R-404A

Test Equipment

The following test equipment was used during the tests:

- Acculab SVI 100-E calibrated scale with a capacity of 100 kg and a resolution of 0.02 kg, serial number 17372505-15511; calibration certificate na6729-725-032415, Mettler Toledo, Montreal, dated March 24, 2015.
- Davis Instrument Vantage Vue weather station (to measure the atmospheric pressure and humidity in the environmental chamber) placed midway along the length of the room on the right side of the vehicle.
- Propower Mfg. Inc. portable tank with a capacity of 68 L (18 gal).
- TROEMNER calibration weights 20 kg, serial no. FP-03, and FP-04; calibration certificate dated March 20, 2015 (Figure 10).
- The data acquisition system used to capture the ambient temperature and humidity in the environmental chamber included:
    - Two type T thermocouples placed midway along the length of the room on both sides of the vehicle;
    - A humidity sensor placed midway along the length of the room on the right side of the vehicle.
- The data acquisition system used to capture the interior temperature of the trailer included:
    - Eleven type T thermocouples: 4 at the front corners of the trailer, 4 at the rear corners of the trailer and 3 in the middle (positions 5, 6 and 7) of the trailer along the longitudinal axle at half the height of the trailer (1.25 m, 49 in). Figure 11 shows a schematic of the positioning of all the thermocouples;
    - One of these thermocouples was placed in the middle of the trailer (at half the length), while the other two were placed at a third of the length of the trailer. Figure 12 shows an image of the 3 thermocouples in the middle of the trailer.

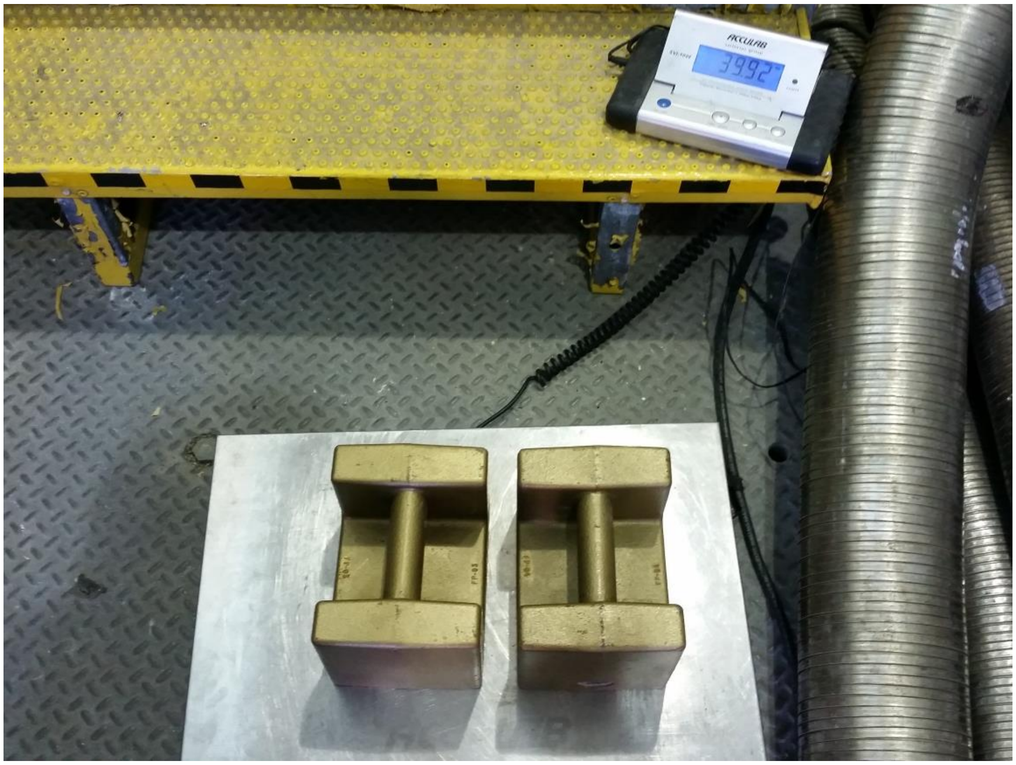

Figure 10. Scale verification using calibration weights

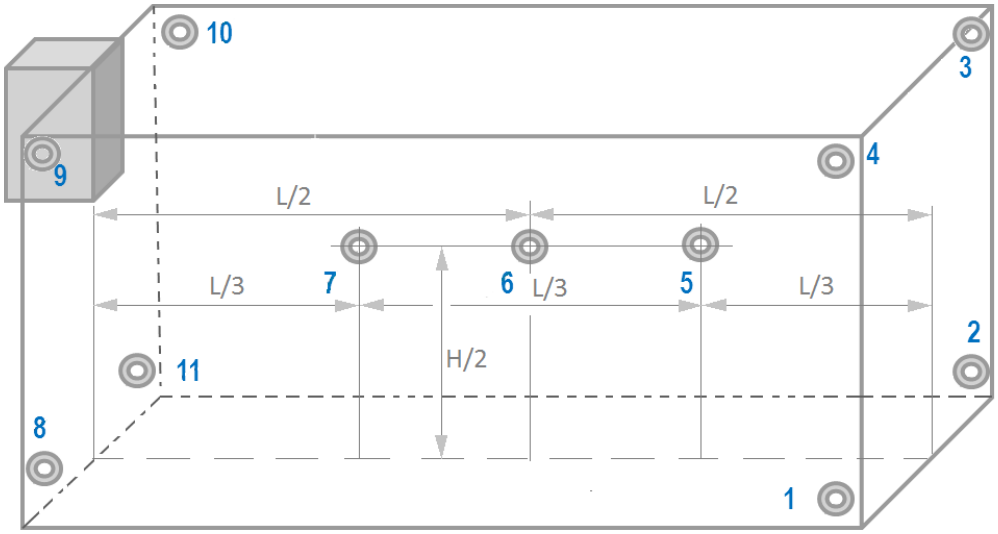

Figure 11. Position of the thermocouples inside the trailer

Figure 12. Position of the three thermocouples in the middle of the trailer

Results

The Baseline segment was carried out without the technology to be tested installed on the reefer. The Baseline test was conducted on September 15th 2015 after the trailer was instrumented with thermocouples and allowed to soak in the set ambient conditions of the environmental chamber overnight (night of September 14th 2015). After the Baseline test, the technology was installed by the technology provider. The test vehicle was then sent into operation and allowed to run for at least 80 hours for the reaction to take place.

The test vehicle was returned to the test site and the Final segment was conducted on September 25th 2015 after the test vehicle was instrumented with thermocouples and allowed to soak in the set ambient conditions of the environmental chamber overnight (night of September 24th 2015).

The results of the fuel consumption test done with IceCOLD installed on the test vehicle showed fuel savings of 14.30% compared to the Baseline segment, when the product was not installed. Table 5 provides a summary of the results.

The repeatability of tests can be evaluated with the coefficient of variation (c_V), defined as the ratio of the standard deviation (σ) to the mean (μ), expressed as a percentage as shown below:

$$c_V = 100 \times \frac{\sigma}{\mu} \tag{3}$$

Table 5 shows that the coefficients of variation of B/F ratios were 6.74% (see discussion on page 21).

Table 5. Summary of the results

Test Run	*Consumed fuel, kg*		*B/F Ratio*	*Fuel savings, F_{Si}, %*
	Baseline Test Segment	*Final Test Segment*		
Bringing temp. to -10 °C				
Conditioning	9.88	8.98	1.100	9.11
Fuel consumption test runs				
1	7.58	6.84	1.108	9.76
2	6.6	5.76	1.146	12.73
3	7.08	5.62	1.260	20.62
Total	**21.26**	**18.22**	**1.167**	**14.30**
Mean B/F Ratio			***B/F coefficient of variation %***	
1.171			6.739	
Fuel savings for the three test runs F_s, %				
14.30				

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Discussions

Test Limitations

Tests done on a road or a test track are subject to variable weather conditions. To ensure that the results are accurate, it is important to eliminate the effect of these variable conditions on the test results. However, if a technology of this type (installed on a refrigerated trailer) is tested on a test track, it is more difficult to eliminate variable external influences on the refrigeration unit's operation, and to determine the trailer's influence on variations in reefer fuel consumption. Therefore, given that reefer tests are highly dependent on ambient conditions, an environmental chamber with controlled conditions (temperature and humidity) was deemed more appropriate for this technology.

The influences of the trailer and reefer were minimized as much as possible by using the same trailer and reefer for both the Baseline and Final segments. Both trailer and reefer were in good operating condition. The same fuel was used for the two segments and its density was 0.824 kg/L.

To minimize the uncertainty surrounding measurements, the weight of the tank was the only parameter considered for the results. However, other parameters were recorded for the purpose of documenting test conditions. To avoid any problems related to instruments, two calibrated scales were available, but only one was used and it was not moved between weighing.

For both segments, the trailer was subjected to virtually identical conditions, as shown in Figure 13, which indicates the variation in temperature during the two soaking periods, measured by the sensors placed in the middle (positions 5, 6 and 7) of the trailer. It must be noted that though the set point for the environmental chamber temperature was +30°C, there are some small variations (less than 1°C) during the soaking periods. These variations do not affect the results of the fuel consumption test.

Figure 14 shows the variation in ambient (chamber) temperature during the tests, measured by the temperature sensors placed in the chamber behind the vehicle. The circled areas highlight temperature drops caused by the cold air from the interior of the trailer during the stops, when the rear doors of the van were open. The high peaks after the doors are closed were caused by overshoots of the chamber temperature control when compensating for the temperature drops.

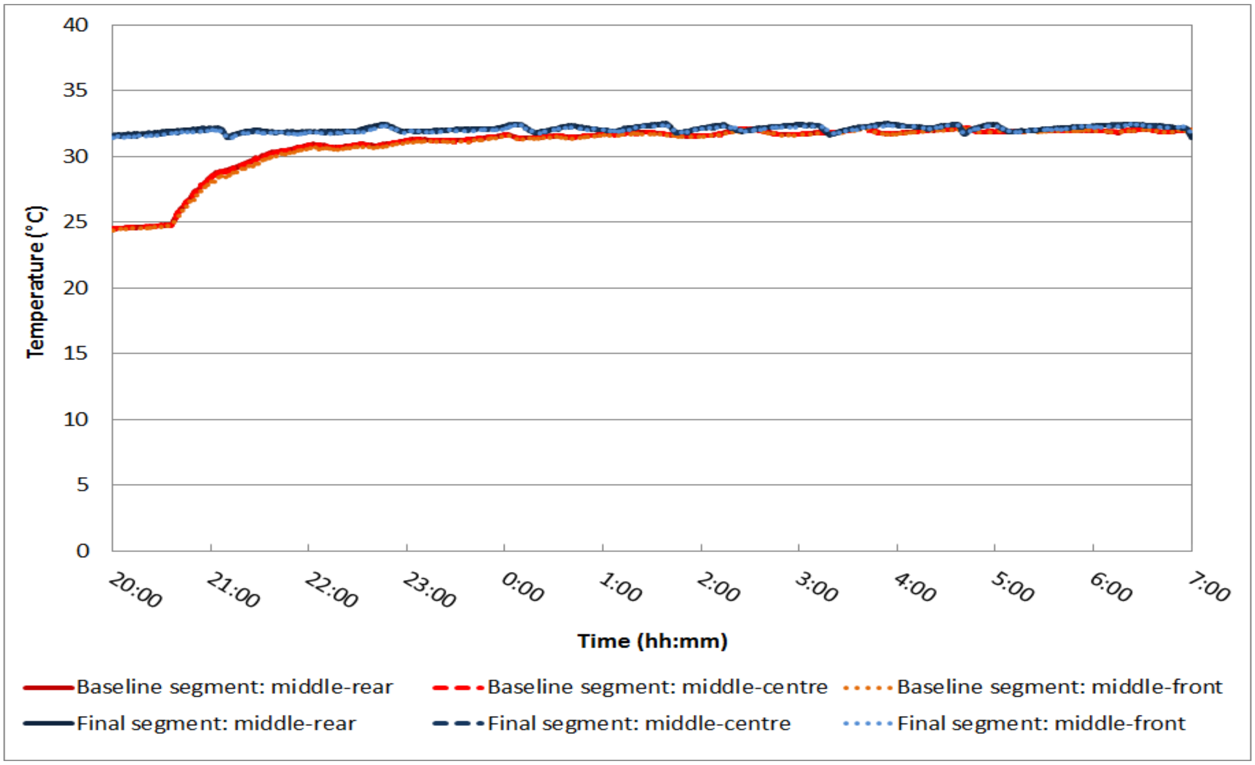


Figure 13. Trailer interiror temperature variations during soaking

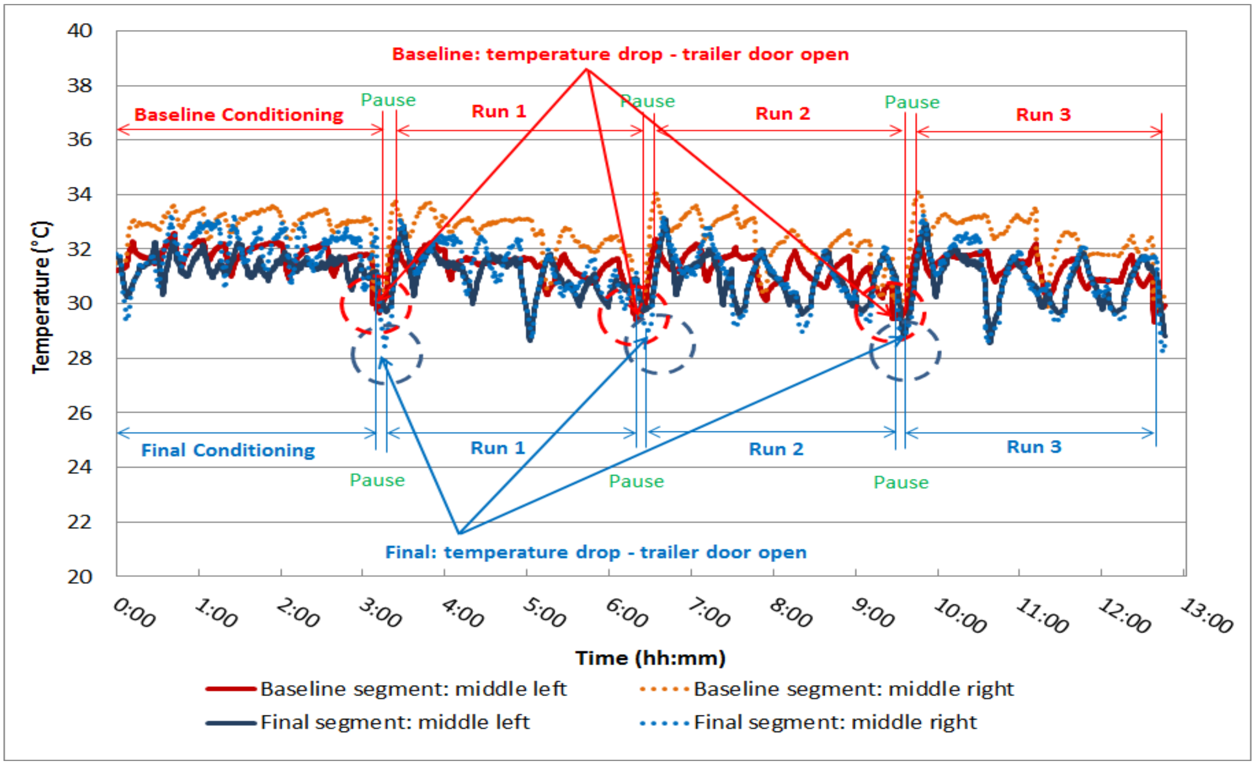


Figure 14. Ambient temperature variations during the tests

Performance of the Tested Technology

Figure 15 shows the variation in trailer interior temperature during the two test segments (Baseline and Final segments), measured by the temperature sensors placed in the middle of the trailer (position 5, 6 and 7). One may observe that during the conditioning stage, the time required to bring the trailer interior temperature to -10 °C was 15 minutes less in the Final test segment (after IceCOLD was installed) compared to the Baseline segment (no technology installed). This may be due to the faster cooling capabilities of IceCOLD as indicated by the technology suppliers.

Figure 16 shows the trailer interior temperature variation for both test segments, measured by the temperature sensor placed in the middle (position 6) of the trailer. This image shows specific fluctuations in trailer interior temperature, which occurred as a result of compressor stops. Table 6 summarizes these occurrences. From this table, it is evident that there were more stops in the Final segment compared to the Baseline segment, which would indicate higher efficiency and less fuel consumption.

In the Baseline segment, the compressor stopped once in the first run (for 7 minutes), twice in the second run (for 18 minutes), and once in the third run (for 9 minutes). This resulted in an average stop time of 6% of the duration of the test. In the Final segment (after IceCOLD was installed), the compressor stopped twice in the first run (for 18 minutes), three times in the second run (for 32.5 minutes) and three times in the third run (for 33 minutes). This resulted in an average stop time of 15% of the duration of the test. This increase of stop time between the Baseline and Final segments could be due to the accelerated cooling of the trailer in the Final segment (after IceCOLD was installed), owing to the faster cooling capabilities of the product as indicated by the technology suppliers.

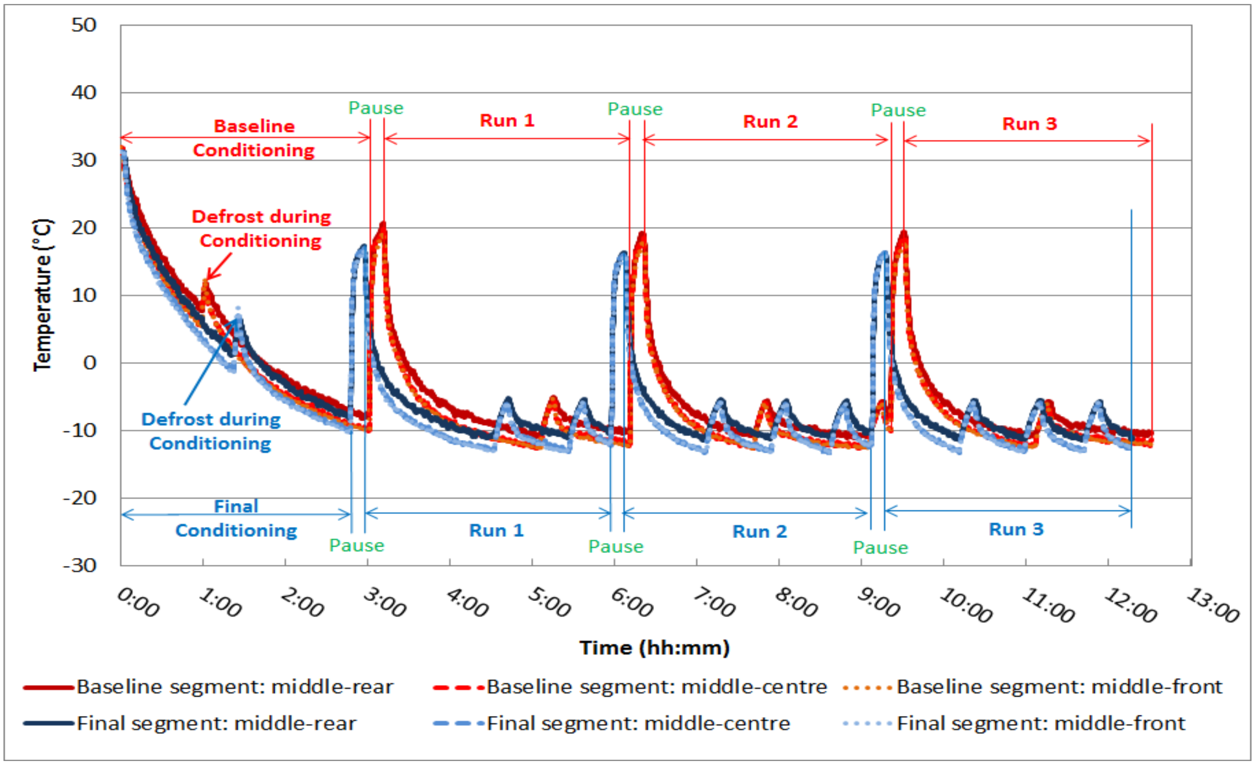


Figure 15. Trailer interior temperature variations during the tests: sensors in the middle of the trailer

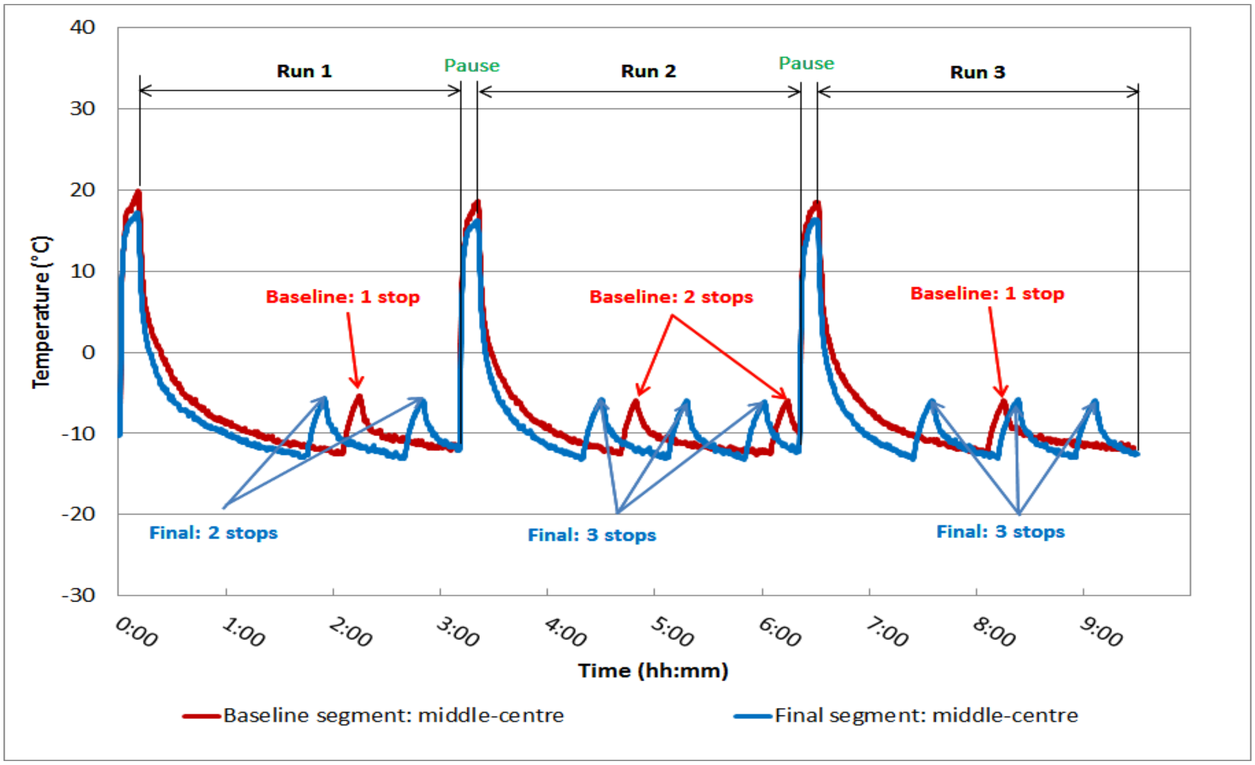


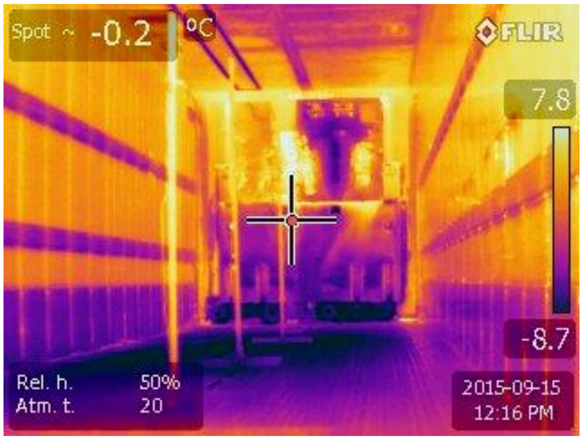
Figure 16. Trailer interior temperature variations during the tests: sensor in the middle of the trailer

Table 6. Number of compressor stops

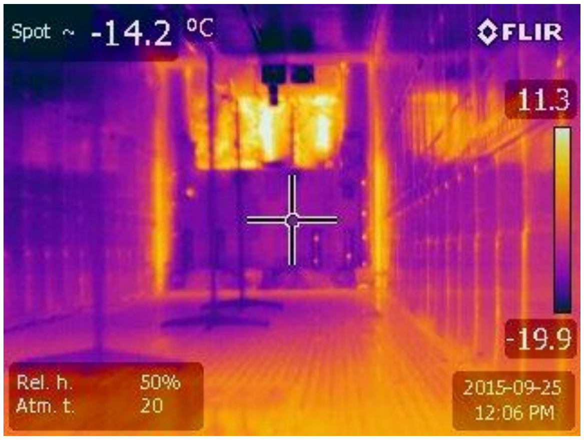
Runs	Stops	Time of Stop	Stop Duration	Test Duration	Stop %
Baseline Conditioning	1	0:58	5	181	2.76%
Baseline Run 1	1	1:57	7	180	3.89%
Baseline Run 2	1	1:20	18	180	10.00%
	2	2:44			
Baseline Run 3	1	1:35	9	180	5.00%
Final Conditioning	1	1:21	4	167	2.40%
Final Run 1	1	1:35	18	180	10.00%
	2	2:30			
Final Run 2	1	0:58	32.5	180	18.06%
	2	1:46			
	3	2:29			
Final Run 3	1	0:53	33	180	18.33%
	2	1:40			
	3	2:24			

It should be noted that with IceCOLD installed, the refrigeration unit consumed less fuel compared to the Baseline segment (see Table 5 and Appendix A). Furthermore, it is evident from the fuel consumption results that the consumption during the Baseline segment was fairly constant. This fuel consumption stabilization achieved in the Baseline segment was not repeated after the installation of the product. Instead, there was a noticeable steady improvement in fuel consumption over the three runs of the Final segment. Accordingly, the resulting variation in B/F ratios are normal and the average calculated result reflects the daily operational condition of this type of vehicle.

Figure 17 shows the thermal images of the front panel of the trailer during tests, which were taken when doors were opened after each test run. One may observe that the temperatures recorded by the thermal camera show much lower front panel temperatures for the Final test runs compared to those of the Baseline. This may be explained by the increased cooling capability of the reefer during the Final segment (after IceCOLD was installed).

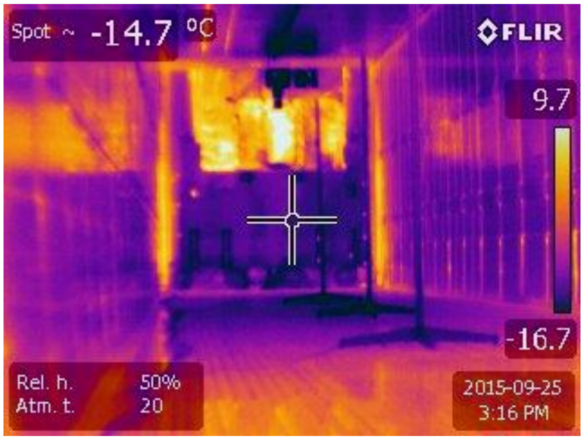


Trailer interior temperature after Baseline Run 1



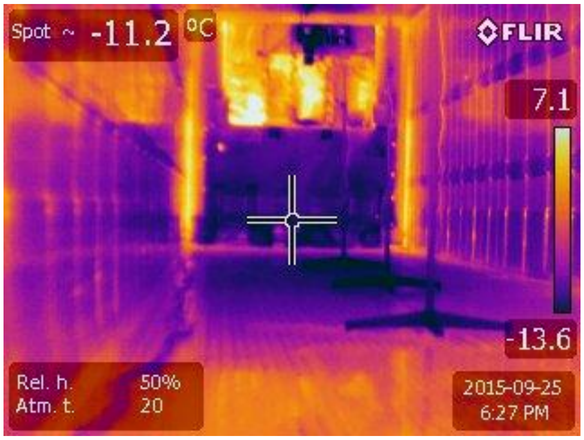
Trailer interior temperature after Final Run 1

Trailer interior temperature after Baseline Run 2



Trailer interior temperature after Final Run 2

Trailer interior temperature after Baseline Run 3



Trailer interior temperature after Final Run 3

Figure 17. Comparison of thermal images: Baseline vs Final segments

Reduction of GHG Emissions and Financial Analysis

GHG Emissions Reduction

The main GHGs released by burning diesel fuel are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Table 7 presents the emission factors for heavy-duty vehicles equipped with diesel engines (Environment Canada 2012).

Table 7. GHG emission factors for heavy-duty diesel vehicles

Type of engine control system	*Emission factor (g/L of diesel fuel)*		
	CO_2	*CH_4*	*N_2O*
Advanced	2663	0.11	0.151
Moderately improved	2663	0.14	0.082
Uncontrolled	2663	0.15	0.075

The CO_2 equivalent GHG emission factor can be calculated using the equivalent GHG potential of 298 times for nitrous oxide, and of 25 for methane, compared with that of carbon dioxide on a per unit mass basis (IPCC 2007), as shown by equation (5):

$$GHG\ Factor\ CO_2^{Equiv} = Factor\ CO_2 + 25 * Factor\ CH_4 + 298 * Factor\ N_2O \qquad (4)$$

For advanced engine control systems (representing the majority of these devices), the CO_2 equivalent GHG emission factor obtained from equation (4) is 2.71 kg CO_2 equivalent per litre of diesel fuel.

As such, given the fuel consumed in the Baseline test segment (21.26 kg), the fuel consumed for a day can be considered to be 25.80 L, calculated with the measured fuel density (0.824 kg/L). Considering an average of 260 working days a year, the annual fuel savings and resulting GHG emissions reduction were calculated to be 959 L and 2.60 tonnes respectively. This is presented in Table 8.

Table 8. GHG emissions reduction

Technology Supplier	*Technology*	*Cons.*	*Work Days*	*Annual Cons.*	*Annual Savings*		*GHG Emissions Reduction*
		L/day	*Days per year*	*L*	*%*	*L*	*Tonnes*
EcoCOOL World	IceCOLD®	25.80	260	6708	14.3	959	2.60

Financial Analysis

The economic impact of various fuel-saving measures is evaluated based on calculations of the payback period or Return on Investment (ROI). The payback period is calculated by dividing the total additional cost of a modification by the annual net savings it provides.

Given the fuel consumption results presented in Table 8, Table 9 presents a number of scenarios obtained by varying the fuel price (increments of 10 cents) and the number of working days per year (260 and 310), calculated in accordance with the Funding Application Guide for project approval - Écocamionnage Program (Transports Québec, 2015), with the following points to note:

- Considering an average of 260 working days per year, the annual fuel savings can be estimated as 959 L and $992, resulting in a Return of Investment (ROI) period of 2.1 years;
- This calculation was made using the average unit diesel price of $1.034/L taken on September 29, 2015 in Canada (NRCan 2015);
- According to information from the technology supplier, EcoCOOL World LLC, the cost of the product is $129 US per ounce and it is a onetime installation for the life of the equipment;
- The quantity of product required is based on the oil charge of the compressor. For the refrigeration unit used in this test, 12 ounces of the product was installed in the low pressure valve of the compressor. This corresponds to a product cost of $2036.39 CAD (calculated with the exchange rate: $1 CAD = $0.76 US). This represents the additional cost per vehicle for installing this technology.

Table 9. Financial Analysis

Technology Supplier	Technology	Additional Cost	Cons.	Work Days	Annual Cons.	Diesel Prices	Annual Savings			ROI
		$	L/day	Days/yr	L	$/L	%	L	$	Years
EcoCOOL World	IceCOLD®	2036.39	25.80	260	6708	0.934	14.3%	959	896	2.3
		2036.39	25.80	260	6708	1.034	14.3%	959	992	2.1
		2036.39	25.80	260	6708	1.134	14.3%	959	1088	1.9
		2036.39	25.80	260	6708	1.234	14.3%	959	1184	1.7
		2036.39	25.80	310	7998	0.934	14.3%	1144	1068	1.9
		2036.39	25.80	310	7998	1.034	14.3%	1144	1183	1.7
		2036.39	25.80	310	7998	1.134	14.3%	1144	1297	1.6
		2036.39	25.80	310	7998	1.234	14.3%	1144	1411	1.4

In addition, while there is minimal maintenance estimated for the use of this technology, it is expected that IceCOLD, as with any new addition to a fleet's preventive maintenance program, will require installation time, as well as several inspections and evaluations to ensure proper operation. These costs must be included in ROI calculations.

Conclusion

Results of the fuel consumption tests performed on the reefer with IceCOLD product supplied by EcoCOOL World, LLC showed fuel savings of 14.30%, which could lead to an annual reduction in GHG emissions of 2.60 tonnes per vehicle.

Given the fuel consumed in the Baseline test segment (21.26 kg), the fuel consumed for a day was taken to be 25.80 L, and an annual fuel savings of 959 L and $992 were calculated. This results in a payback period of 2.1 years.

Disclaimer

The results pertain only to the vehicle and technology sample tested according to the procedures and conditions described in this report. FPInnovations cannot guarantee the reproducibility of these results in particular operating conditions.

Technology supplier representatives were present during the tests involving their product. These representatives also validated the installation of their technology on the vehicle used to perform the tests and acknowledged that the tests were conducted in conformity with the test protocol.

References

Environment Canada. 2012. National Inventory Report, 1990-2010: Greenhouse Gas Sources and Sinks in Canada, Part 2, Annex 8, Table A8–11 Emission Factors for Energy Mobile Combustion Sources, p 199. ISSN: 1910-7064, Ottawa, ON.

IPCC. 2007. Climate Change 2007 Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.) IPCC, Geneva, Switzerland. pp 104.

IceCOLD. 2015. About IceCOLD. http://www.icecold2.com/about-icecold/ (Consulted on October 3, 2015).

Natural Resources Canada (NRCan). 2015. Energy Sector. Energy Sources. Petroleum Products and Crude Oil Prices. http://www2.nrcan.gc.ca/eneene/sources/pripri/price_map_e.cfm (Consulted on October 3, 2015).

SAE International. 2012. Fuel Consumption Test Procedure – Type II, SAE Surface Vehicle Recommended Practice J1321. Warrendale, PA.

SAE International. 1987. Joint TMC/SAE Fuel Consumption Test Procedure - Type III, SAE Surface Vehicle Recommended Practice J 1526. Warrendale, PA.

Transports Québec. 2014. Guide de demande d’aide financière pour un projet d’homologation - Programme Écocamionnage. http://www.mtq.gouv.qc.ca/centredocumentation/Documents/services-transport-routier/guide-demande-aide-financ-proj-homologation.pdf (Consulted on October 3, 2015).

Appendix A – Result Sheet

BASELINE - IceCOLD® Not Installed	September 15 2015									
Ambient Environmental Conditions										
Description	*Interior Temp. at Start, °C*	*Ambient Temp., °C*			*Pressure, hPa*			*Humidity, %*		
		Start	*Mid*	*End*	*Start*	*Mid*	*End*	*Start*	*Mid*	*End*
Bringing the Interior Temperature to -10°C										
Conditioning	31.21	31.20	31.95	31.81	1023.80	1023.80	1023.80	57.07	49.07	43.00
Tests at Constant Interior Temperature (-10°C)										
Baseline Run 1	19.52	32.19	31.63	30.47	1023.70	1023.70	1023.40	43.00	41.23	43.82
Baseline Run 2	18.44	30.52	30.68	30.73	1023.30	1022.70	1022.70	35.44	42.38	43.34
Baseline Run 3	18.48	30.14	31.48	31.08	1022.60	1022.60	1022.90	36.53	40.72	43.15

Fuel Consumption Measurements						
Description	*Time*			*Tank Weight, kg*		
	Start	*End*	*Diff., min*	*Start*	*End*	*Diff.*
Bringing the Interior Temperature to -10°C						
Conditioning	7:05:00	10:06:00	181	61.60	51.72	9.88
10 min pause with door open	10:06:00	10:16:00	10			
Tests at Constant Interior Temperature (-10°C)						
Baseline Run 1	10:16:00	13:16:00	180	51.72	44.14	7.58
10 min pause with door open	13:16:00	13:26:00	10			
Baseline Run 2	13:26:00	16:26:00	180	44.14	37.54	6.60
10 min pause with door open	16:26:00	16:36:00	10			
Baseline Run 3	16:36:00	19:36:00	180	37.54	30.46	7.08
Total fuel consumption for three runs at constant temperature, kg						**21.26**

FINAL - IceCOLD® Installed	September 25 2015									
Ambient Environmental Conditions										
Description	*Interior Temp. at Start, °C*	*Ambient Temp., °C*			*Pressure, hPa*			*Humidity, %*		
		Start	*Mid*	*End*	*Start*	*Mid*	*End*	*Start*	*Mid*	*End*
Bringing the Interior Temperature to -10°C										
Conditioning	31.22	32.00	32.00	31.00	1031.10	1032.10	1032.40	27.00	26.00	25.00
Tests at Constant Interior Temperature (-10°C)										
Final Run 1	17.26	29.80	31.60	30.92	1032.40	1031.80	1031.10	20.06	18.20	19.29
Final Run 2	15.95	29.88	31.04	31.04	1030.80	1030.40	1029.60	17.56	18.39	18.21
Final Run 3	16.24	29.77	30.66	31.00	1029.60	1029.90	1030.00	17.12	19.96	27.00

Fuel Consumption Measurements						
Description	*Temps*			*Tank Weight, kg*		
	Start	*End*	*Diff., min*	*Start*	*End*	*Diff.*
Bringing the Interior Temperature to -10°C						
Conditioning	7:16:00	10:03:00	167	61.22	52.24	8.98
Pause 10 min with door open	10:03:00	10:13:00	10			
Tests at Constant Interior Temperature (-10°C)						
Final Run 1	10:13:00	13:13:00	180	52.24	45.40	6.84
10 min pause with door open	13:13:00	13:23:00	10			
Final Run 2	13:23:00	16:23:00	180	45.40	39.64	5.76
10 min pause with door open	16:23:00	16:33:00	10			
Final Run 3	16:33:00	19:33:00	180	39.64	34.02	5.62
Total fuel consumption for three runs at constant temperature, kg						**18.22**

RESULTS	
Fuel savings for Run 1	9.76%
Fuel savings for Run 2	12.73%
Fuel savings for Run 3	20.62%
Fuel savings at constant temperature	**14.30%**

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For further information:

Adime Kofi Bonsi, Eng., M.Eng. (Researcher – Technology Testing)

adime.bonsi@fpinnovations.ca

☎ 514 782-4696

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

marius.surcel@fpinnovations.ca

☎ 514 782-4519

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

www.pit.fpinnovations.ca
www.fpinnovations.ca

PIT Group
by FPInnovations