

**Fuel Consumption Evaluation of the  
Equity Transportation Green Truck  
Using Portable Emissions Measurement Systems**

**Prepared for: Equity Transportation Company**

**Prepared by: Emisstar LLC**

*September 21, 2009*



*Michael C. Block  
Glenn P. Goldstein  
Saeed Abolhasani*

## 1. Objective

The objective of this test program was to evaluate the performance of Equity Transportation Company's ("Equity") Green Truck ("GT"), a remanufactured long-haul Class Eight tractor equipped with a variety of leading sustainable transportation technologies to improve fuel economy under real-world operating conditions utilizing a portable emissions measurement system ("PEMS").

## 2. Test Description

Development of the test protocol involved selection of an appropriate in-use test procedure that is representative of real world trucking operations and an appropriate truck for actual PEMS testing. Normally, fuel economy is measured using a portable emissions measurement system (PEMS) following SAE J1321 test procedures. The basis for this type of test references protocols developed by SAE, EPA and the Truck Maintenance Council (TMC) of the American Trucking Associations (ATA) for in-use emissions testing using PEMS. The protocol is predicated upon the use of two trucks encompassing the rolling baseline concept. However, because Equity wished to quantify the fuel consumption benefits of an entire package – essentially a new truck – the two truck/rolling baseline approach did not apply. This one truck approach does not diminish the value of the test or the validity of the test results; however, it does require comparison to fleet documentation of fuel consumption (i.e., "industry reference"). As such, by exercising the test vehicle over a prescribed, highly repeatable route there is a high degree of assurance that actual reported results are indicative of real world operating conditions.

### 2.1. Test Vehicle

For this test, one Class 8 heavy-duty GT was selected from the Equity fleet. Table 1 exhibits GT chassis and engine information.

**Table 1 – Test Truck Chassis and Engine Information**

<b>Category</b>	<b>Type</b>
<b>Chassis</b>	
Vehicle Description	Class 8
License Plate	
VIN	1FVXA70048LZ68279
Manufacturer/Year	08/07
Vehicle Interface Type	J1708
<b>Engine</b>	
Manufacturer/ Year	Detroit Diesel / 2002
Engine Model	Series 60
Engine Serial Number	6R-456559
Rated HP	500
Engine Family	2DDXH12.7EGL
Rated Engine Speed	2100
Displacement	12.7
<b>Emission Certification Values</b>	
NO <sub>x</sub> (g/bhp-hr)	3.8
THC (g/bhp-hr)	0.2
PM (g/bhp-hr)	0.08
CO (g/bhp-hr)	1.2
<b>General Information</b>	
Total weight with empty trailer	
Total weight with loaded trailer	

The Equity GT is also equipped with advanced technologies to make the vehicle at greater efficiencies. A summary of the complete sustainable transportation technology package is provided in Table 2:

**Table 2 – Sustainable Transportation Technologies**

Category	Type
<b>Tires</b>	
Manufacturer	Michelin
Front Axle	XZA3
	275/80R22, 5(G)
First Int. and Rear Axle	XDA-HT Plus
	445/50R22, 5(L)
<b>JetStar Hydrogen System</b>	
Manufacturer	Dynamic Fuel Systems
Model	
Serial Number	
Principle	Hydrolysis
Rating	59 amps
<b>Trailer</b>	
Manufacturer	Trailmobile Canada Ltd
Type	Super Light weight AL
<b>Other</b>	
5 <sup>th</sup> Wheel	All-Aluminum
High Efficiency Fan	Alan Bishop

To replicate payload conditions over the test cycle, a secure load from an existing Equity customer was used with a weight of 32,500 pounds. One thoroughly trained, CDL Class A driver with 12 years experience was used throughout the test program. This individual possessed consistent driving skills and performed a series of trial test cycles prior to performing the actual baseline and final tests in order to ensure that the cycles were driven as intended.

## 2.2. Test Cycles

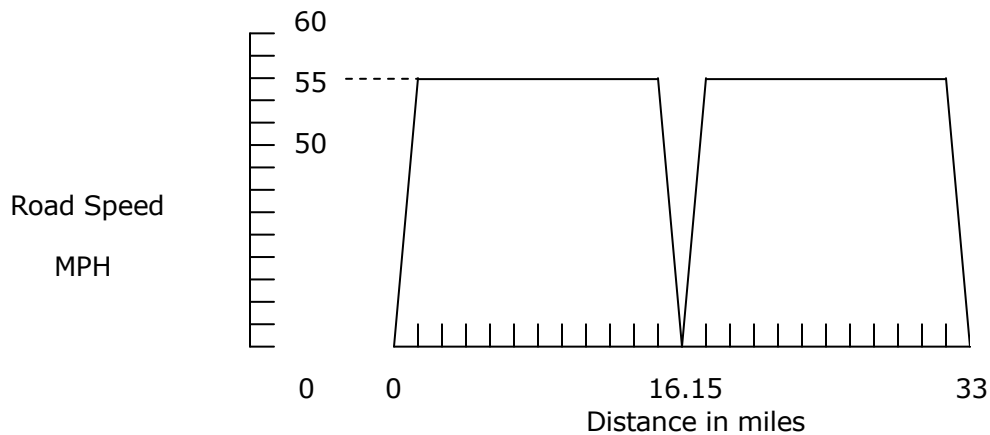
A test cycle was developed for this program to reflect interstate highway driving patterns and provide a basis for evaluating the GT steady-state high speed fuel economy performance. Figure 1 provides a diagram of the test cycles established for this test program according to SAE J1321 protocols. A test cycle consisted of one (1) trip loop for the GT. Each loop consisted of the Westbound and Eastbound legs of the highway (see test location in Section 2.3 for further details). The following steps were taken to complete one test cycle:

1. Start from the starting mile marker (Westbound leg of the highway)
2. Obtain a steady speed of 55 mph or 60 mph and maintain the speed for 16.18 miles

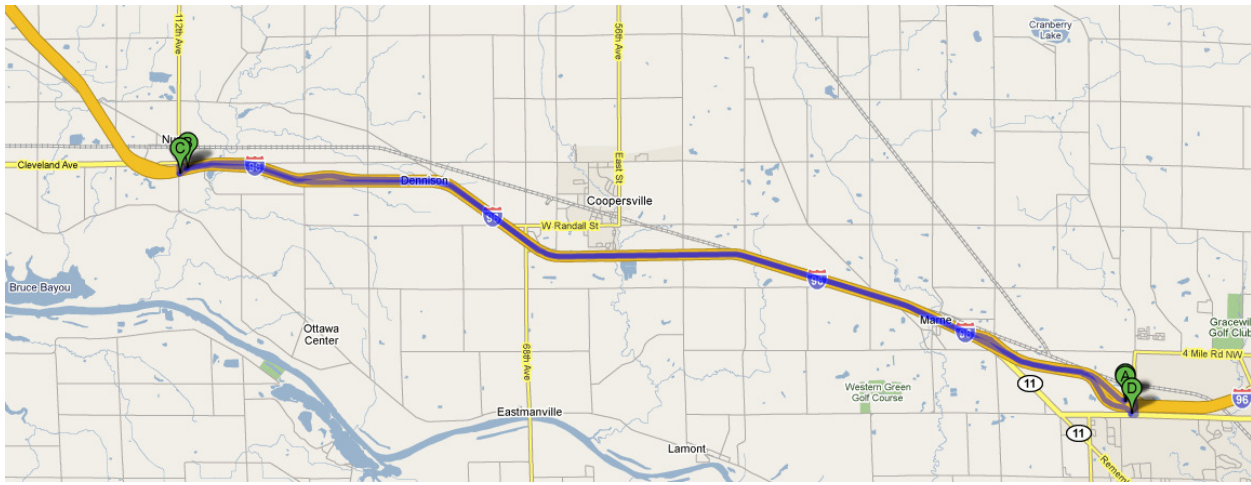
3. Stop at the stopping mile marker (Westbound leg of the highway)
4. Make a U-turn
5. Start from the starting mile marker (Eastbound leg of the highway)
6. Obtain a steady speed of 55 mph or 60 mph and maintain the speed for 16.10 miles
7. Stop at the stopping mile marker (Eastbound of the highway)

### 2.3. Test location

Testing took place at the Westbound and Eastbound legs of Interstate-96 in Walker, Michigan as shown in Figure 2. The test route was selected to minimize interfering traffic as much as possible. On average, each test loop consisted of 16.18 miles on the Westbound leg and a 16.10 miles return the Eastbound leg. Trucks were operated at 55 mph and 60 mph, in order to quantify differences in fuel economy performance at different speeds and stay within the legal State of Michigan speed limit.



**Figure 1 – Test Cycles Deployed for Fuel Economy Evaluation**



**Figure 2** – Test Location: Westbound and Eastbound Lanes of I-96; Walker to Nunica, Michigan

## 2.4. Test Phases

Testing was comprised of three major phases: the standard segment, reduced speed segment and the increased hydrogen segment.

- (1) **Standard Speed- Standard Jetstar Setting:** An initial test was performed on June 23, 2009. For this test, the GT performed the test cycles a number of times at standard settings (speed = 60 MPH, HFR Injection = 59 amps) to make up a minimum of three valid T ratios (test vehicle fuel used). Valid T ratios were acceptable within 2% variation as per SAE J1321 guidelines.
- (2) **Reduced Speed - Standard Jetstar Setting:** A second test was performed on June 24, 2009. For this test, the GT performed the test cycle a number of times at a reduced speed of 55 MPH with a standard HFR setting to achieve a minimum of three valid T ratios (within 2% variation).
- (3) **Standard Speed - Increased Jetstar Setting:** The final test phase was performed concurrently with the second test phase. For this test, an Equity mechanic adjusted the HFR system settings to the maximum achievable amperage (62 amps). For consistency, the same driver, vehicle, trailer and payload were used for testing as in the initial and second test. The truck performed the same test cycles a number of times (minimum three), until it was statistically established that the results were within 2% variation.

## 2.5. Testing System

Emisstar utilized one SEMTECH-DS™ mobile emissions analyzer on the GT to provide a unique combination of fuel economy and emissions measurement. The SEMTECH-DS has been used by the EPA for fuel economy evaluation on diesel trucks.

### 3. Discussion and Results

#### 3.1. Fuel Economy

Fuel economy calculated by the SEMTECH during Baseline and Final test phases met SAE J1321 requirements of 0.5% time difference between loops and 2% spread in T ratio. These differences are attributable to weather, road conditions and the consistency of the drivers in repeating the experiment. Fuel economy was calculated for each test round using the combined fuel economy results for the West and Eastbound legs.

For the Standard Speed – Standard Jetstar test segment, four consecutive test rounds were performed, with the final three test rounds accommodating a spread of 2% and consistent fuel economy values. For the Reduced Speed – Standard Jetstar and Standard Speed-Increased Jetstar test segments, three consecutive trials accommodated the 0.2% error—well within the 2% spread requirement. For all segments, the minimum acceptable ratios were calculated according to SAE J1321 by using the highest values multiplied by 0.97 confidence level. Table 3 summarizes the fuel economy results for the three test phases and quantifies average fuel economy over the test cycles. The strict repeatability requirements of the SAE J1321 specification were met and data for the three test rounds are valid.

**Table 3 – Summary of Fuel Economy Results**

Test Description	Test Round	Test Segment	Fuel Economy (mpg)	Average Fuel Economy per Test Round (mpg)
Standard Speed - Standard Jetstar Setting	1	1	8.800	8.454
		2	8.108	
	2	1	8.318	8.096
		2	7.873	
	3	1	8.444	8.060
		2	7.676	
Reduced Speed – Standard Jetstar Setting	1	1	8.858	8.570
		2	8.281	
	2	1	9.030	8.820
		2	8.610	
	3	1	8.790	8.695
		2	8.599	
Standard Speed – Increased Jetstar Setting	1	1	7.515	7.915
		2	8.314	
	2	1	7.508	7.826
		2	8.143	
	3	1	7.538	7.807
		2	8.075	



**Table 4 – Summary of Fuel Economy, Exhaust Gas Temperature and Wind Speed /Direction**

Test Description	Test Round	Test Segment	Fuel Economy (mpg)	Exhaust Gas Temperature (°C)	THC [g/mile]	THC [g/bhp-hr]	Wind Speed - Direction (mph)
Standard Speed - Standard Jetstar Setting	1	1	8.800	284	0.108	0.054	5.2 – SW (T <sup>1</sup> )
		2	8.108	304	0.108	0.050	5 – SW (H <sup>2</sup> )
	2	1	8.318	287	0.165	0.078	4 – SW (T)
		2	7.873	304	0.161	0.072	4– SW (H)
	3	1	8.444	285	0.175	0.084	4 – SW (T)
		2	7.676	304	0.199	0.087	4 – SW (H)
Reduced Speed – Standard Jetstar Setting	1	1	8.858	278	0.082	0.045	5 – S (C <sup>3</sup> )
		2	8.281	291	0.081	0.041	4 – S (C)
	2	1	9.030	273	0.121	0.067	4 – S (C)
		2	8.610	288	0.117	0.061	4 – S (C)
	3	1	8.790	278	0.118	0.063	4 – S (C)
		2	8.599	290	0.112	0.058	5 – S (C)
Standard Speed – Increased Jetstar Setting	1	1	7.515	319	0.103	0.044	6 – NW/N (H)
		2	8.314	301	0.114	0.054	7 – NW/N (T)
	2	1	7.508	312	0.107	0.046	9 – NW/N (H)
		2	8.143	308	0.101	0.047	10 – NW/N (T)
	3	1	7.538	310	0.116	0.049	13 – W (H)
		2	8.075	308	0.108	0.049	15 – W (T)

T: Tailwind  
H: Headwind  
C: Crosswind

## Ambient Conditions

Table 5 summarizes the average ambient conditions for the test phases.

**Table 5 – Ambient Parameters Recorded During The Test Phases**

Test Description	Test Round	Ambient Temperature (°C)	Barometric Pressure (mbar)	Relative Humidity (%)
Standard Speed - Standard Jetstar Setting	1	31	990	57
	2	29	990	62
	3	28	990	68
Reduced Speed - Standard Jetstar Setting	1	32	990	56
	2	34	990	52
	3	35	991	48
Standard Speed - Increased Jetstar Setting	1	37	989	38
	2	36	989	40
	3	35	989	42

## 4. Test Data Files

All test data files resulting from the testing program have been shared with Equity. Files are identified using the following abbreviations:

- R1 = Round 1
- R2 = Round 2
- R3 = Round 3
- S1 = Segment 1
- S2 = Segment 2
- TT = Test Truck
- Raw = Raw Data Set