



# **AUTOMOTIVE TESTING AND DEVELOPMENT SERVICES, INC.**

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## **Emission**

*FTP Protocol  
SFTP Protocol  
Euro Protocols  
Asia Protocols  
Evaporative Emissions  
NMOG Determination  
Electric Vehicle Range  
Hydrocarbon Speciation  
New Vehicle Certification  
In-Use Verification  
Gasoline  
Diesel*

## **Durability**

*Passenger Cars  
Light-Duty  
Medium-Duty  
Heavy-Duty  
Highway Motorcycles  
Non-road Motorcycles  
Non-road UTV/ATV  
Component  
On-road (Public Roads)  
Proving Grounds  
Temporary Test Sites  
OBD System Download  
Custom Data Logging*

## **Engineering**

*SAE Coast-Downs  
SAE Fuel Economy  
SAE OBD Compliance  
CFR Testing and Procedures  
CCR Testing and Procedures*

## **Procurement**

*OEM In-Use  
Agency In-Use  
Component Collection  
Data Collection  
Usage Surveys*

## **Staffing**

*Drivers  
Mechanics  
Data Technicians  
Maintenance  
Administrative  
Lab Technicians*

May 26<sup>th</sup>, 2017

W. Leighton Good  
Manager, Product and Applications  
Mitsubishi Fuso Truck of America, Inc.

## **Re: Mitsubishi Fuso Comparative Fuel Economy Trial**

Dear Mr. Good,

Automotive Testing and Development Services, Inc. (ATDS) is pleased to provide this final report on the comparative fuel economy test program provided for Mitsubishi Fuso Truck of America, Inc. (MFTA). The purpose of this project was to conduct a comparative fuel economy trial of three Class 4 diesel-powered commercial vehicles as an independent third-party laboratory.

The comparative fuel economy trial was conducted to determine and measure the fuel consumption difference between three Class 4 diesel-powered commercial vehicles, a Model-Year 2017 Mitsubishi Fuso FE160, a Model-Year 2016 Isuzu NPR-XD, and a Model-Year 2016 Hino 155. The testing was conducted by ATDS between the dates of April 27<sup>th</sup>, 2017 and May 22<sup>nd</sup>, 2017. The project consisted of operating the vehicles simultaneously over an on-road test route, for a total of ten (10) valid circuits of the test route. Five (5) of the circuits were conducted with the Mitsubishi Fuso vehicle in "ECO mode". The fuel consumption was gravimetrically measured in auxiliary fuel tanks retrofitted on the vehicles and two (2) calibrated scales to measure the fuel tanks before and after each circuit.

The 2017 Mitsubishi Fuso FE160 consumed 8% less fuel than the 2016 Hino 155 and 5% less than the 2016 Isuzu NPR-XD over the ten (10) circuit runs. For the circuits conducted with "ECO mode" on, the 207 Mitsubishi Fuso FE160 consumed 10% less fuel than the 2016 Hino 155 and 9% less than the 2016 Isuzu NPR-XD.

Sincerely,

Approved by:

Oscar Garcia  
Test Engineer

Linwood Farmer  
Vice President



## Comparison Fuel Economy Trial

Project Number: 2522

CONDUCTED FOR:

Mitsubishi Fuso Truck of America, Inc.  
2015 Center Square Road  
Logan Twp., NJ 08085

REPORT PREPARED BY:

Oscar Garcia, Test Engineer  
Automotive Testing and Development Services, Inc.  
400 South Etiwanda Avenue  
Ontario, California 91761

Automotive Testing and Development Services, Inc. submitted this Report in fulfillment of Project 2522 Mitsubishi Fuel Economy Trial. In ATDS' professional opinion this testing was conducted in a valid manner according to the listed methodology.



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## **INTRODUCTION**

Automotive Testing and Development Services, Inc. (ATDS) was contracted by Mitsubishi Fuso Truck of America, Inc. (MFTA) to conduct a fuel economy trial of a 2017 Mitsubishi Fuso FE160, a 2016 Isuzu NPR-XD, and a 2016 Hino 155 operating under identical test conditions.

Fuel economy is a major factor in a potential buyer's decision process when selecting truck purchases. Even a small improvement in fuel economy makes a significant difference when compounded with multiple units over many miles of operation. The purpose of this test program was to quantify the difference in fuel economy between the 2017 Mitsubishi Fuso FE160 and each of the competitive trucks, 2016 Isuzu NPR-XD and 2016 Hino 155. Figure 1 below shows the three test trucks prior to the start of a circuit. The test trucks were sourced by MFTA from dealers locally to the ATDS facility and were picked up by ATDS directly from the dealers.



Figure 1. (Left to Right) Isuzu NPR-XD, Hino 155, and Mitsubishi Fuso FE160.

The procedure used for this program was in accordance with ATDS standard practices with basic requirements per SAE J1321 Fuel Consumption Test Procedure in combination with SAEJ1264 Fuel Consumption Test Procedure.



## TEST PROCEDURE

### Test Vehicles

The Mitsubishi Fuso test truck was obtained from TransWest Truck Center located at 10150 Cherry Ave, Fontana, CA 92335. The vehicle had the following specifications:

ATDS Vehicle ID:	2522-01
MY/Make/Model:	2017 Mitsubishi Fuso FE160
VIN:	JL6BNG1A3HK001922
Engine Family:	GFPXH03.0F1B
GVWR:	15995 lbs.
GAWR Front:	6390 lbs.
GAWR Rear:	12700 lbs.
Date of Manufacture:	12/16
Odometer:	43 miles
Check-In Weight:	7983 lbs.
Driver Weight:	240 lbs.
Full Auxiliary Fuel Tank Weight:	112.7 lbs.
Added Ballast:	6154 lbs.
Vehicle Test Weight:	14500 lbs.

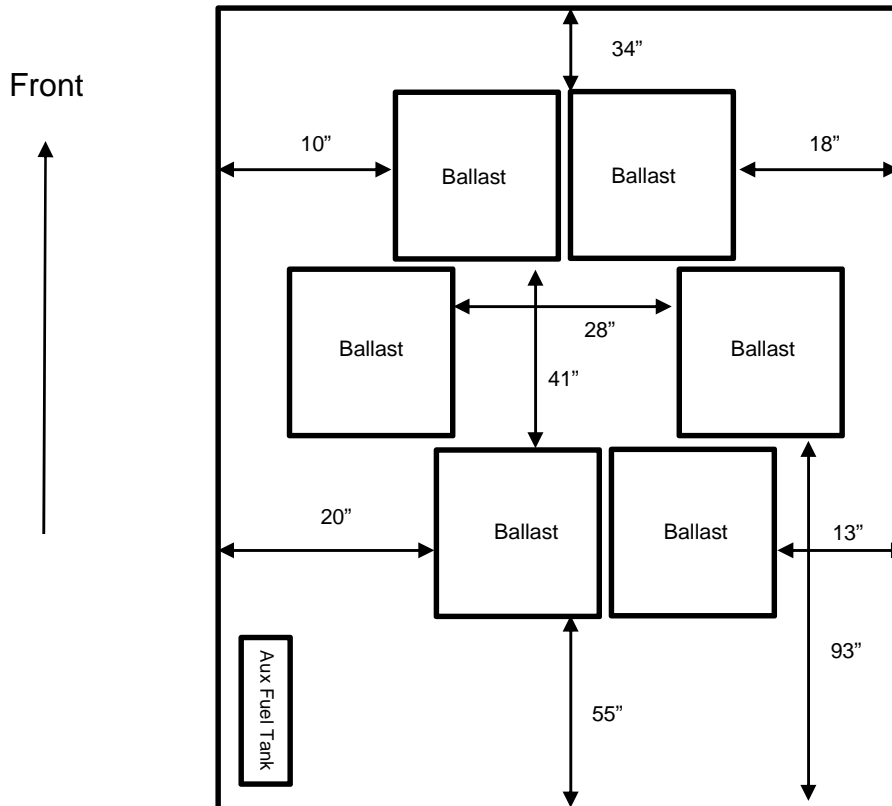


Figure 2. Location of the ballast (sand bags) in the box of 2522-01.



## AUTOMOTIVE TESTING AND DEVELOPMENT SERVICES, INC.

The Hino 155 test truck was obtained from Tom's Truck Center located at 1008 E. 4<sup>th</sup> Street, Santa Ana, CA 92701. The vehicle had the following specifications:

ATDS Vehicle ID:	2522-02
MY/Make/Model:	2016 Hino 155
VIN:	JHHYDM1H9GK003199
Engine Family:	FHMXH05.1JTP
GVWR:	14500 lbs.
GAWR Front:	5950 lbs.
GAWR Rear:	9880 lbs.
Date of Manufacture:	10/15
Odometer:	14531 miles
Check-In Weight:	10020 lbs.
Driver Weight:	240 lbs.
Full Auxiliary Fuel Tank Weight:	121.9 lbs.
Added Ballast:	4118 lbs.
Vehicle Test Weight:	14500 lbs.

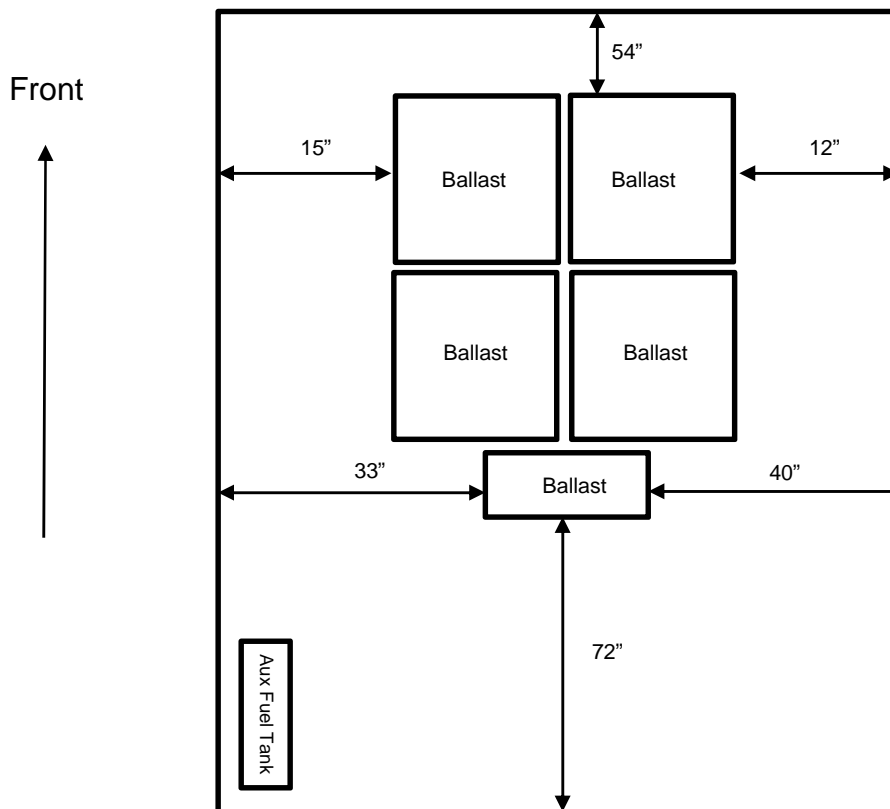


Figure 3. Location of the ballast (sand bags and lead box) in the box of 2522-02.



# AUTOMOTIVE TESTING AND DEVELOPMENT SERVICES, INC.

The Isuzu NPR-XD test truck was obtained from Tom's Truck Center located at 1008 E. 4<sup>th</sup> Street, Santa Ana, CA 92701. The vehicle had the following specifications:

ATDS Vehicle ID:	2522-03
MY/Make/Model:	2016 Isuzu NPR-XD
VIN:	JALC4W165G7002348
Engine Family:	FSZXH05.23FA
GVWR:	14,500 lbs.
GAWR Front:	5360 lbs.
GAWR Rear:	9880 lbs.
Date of Manufacture:	07/2015
Odometer:	257 miles
Check-In Weight:	8519 lbs.
Driver Weight:	240 lbs.
Full Auxiliary Fuel Tank Weight:	111.3 lbs.
Added Ballast:	5629 lbs.
Vehicle Test Weight:	14500 lbs.

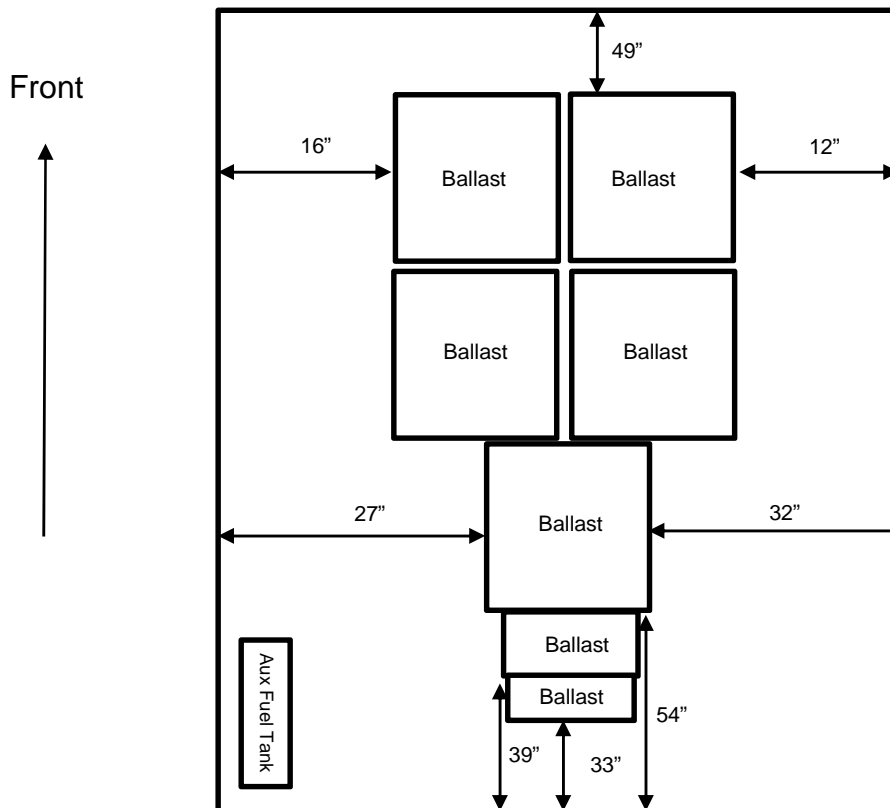


Figure 4. Location of the ballast (sand bags and lead boxes) in the box of 2522-03.



Each test truck was retrofitted with an approximately fifteen (15) gallon auxiliary fuel tank. The auxiliary fuel tanks were the only source of diesel fuel for the trucks for the duration of the test circuit runs. The fuel tanks were mounted in the box of each truck as shown in the schematics, figures 2 through 4. Quick disconnect connections were used in the fuel supply and fuel return lines of the auxiliary fuel tank to allow quick disconnections for fuel tank weighing.

Prior to the start of testing, each truck had a front end alignment to set the steer tires to manufacturer's specifications if necessary. Each truck was equipped with a Race Logic GPS data logger and a Rosco Video GPS data logger. The trucks were ballasted using one-thousand (1000) pound masonry sand bags, lead weight boxes ranging in weight from one-hundred (100) to five-hundred (500) pounds, and TruWeight Sand Bags ranging in weight from five (5) to fifty (50) pounds. All fuel used was commercial grade ultra-low sulfur #2 diesel sourced from local fuel stations from the same pump and dispensed from barrels stored at the ATDS facility. All trucks were equipped with automatic transmissions and were operated solely in the "D" Drive setting and no electric exhaust brake was used for the duration of the program. The trucks were equipped with Diesel Exhaust Fluid reservoirs and those were topped off prior to the beginning of the testing. Any accessories that would have pulled auxiliary power were used in an identical manner in all trucks for the duration of the testing. Each truck was operated with the same HVAC settings for each circuit and the windows closed for the duration of the testing. Lastly, all tires were adjusted to be within five (5) pounds per square inch of the manufacturer's recommended cold tire inflation pressure, one-hundred (100) pounds per square inch for vehicles 2522-01 and 2522-02 and eighty (80) pounds per square inch for vehicle 2522-03.

Once the trucks were approximately ballasted, the trucks were officially weighed at a local Certified Automated Truck (CAT) Scale Fontana Truck Stop located at 14264 Valley Blvd., Fontana, CA. The trucks were weighed fully fueled, ballasted, and instrumented and without a driver. Based on the official weight measurements, the ballast was slightly adjusted by adding or removing TruWeight Sand Bags to reach a Test Weight of 14500 pounds on all three trucks.

Truck: 2522-01 Mitsubishi Fuso FE160  
Official Weight: 14400 lbs.  
Steer Axle: 4600 lbs.  
Drive Axle: 9800 lbs.  
Weight Removed: 140 lbs.

Truck: 2522-02 Hino 155  
Official Weight: 14240 lbs.  
Steer Axle: 4960 lbs.  
Drive Axle: 9280 lbs.  
Weight Removed: 20 lbs.





Truck: 2522-03 Isuzu NPR-XD  
Official Weight: 14260 lbs.  
Steer Axle: 5060 lbs.  
Drive Axle: 9200 lbs.  
Weight Removed: 0 lbs.

### **Test Drivers**

Four (4) test drivers were used, three regular drivers and one fill-in driver. The drivers' weight was adjusted to the heaviest driver, 240 pounds, using TruWeight Sand Bags. Each driver was appointed the appropriate weight in sand bags that were kept with the driver in the passenger side foot well of the test truck the driver was assigned to for that particular circuit.

ATDS Driver ID: A  
Driver Name: Oropeza L.  
Weight: 240 lbs.  
Additional Weight: 0 lbs.

ATDS Driver ID: B  
Driver Name: Walt S.  
Weight: 155 lbs.  
Additional Weight: 85 lbs.

ATDS Driver ID: C  
Driver Name: Chad M.  
Weight: 205 lbs.  
Additional Weight: 35 lbs.

ATDS Driver ID: D (fill-in)  
Driver Name: Oscar G  
Weight: 220 lbs.  
Additional Weight: 20 lbs.

### **Test Route**

As shown in Figure 5 below, the test route is comprised of city sections (heavy traffic with stop and go conditions), suburban sections (higher speeds, some stops with longer drives in between), and highway sections (high speed roads with long stretches with no stops). Each circuit consisted of ninety-seven (97) miles, two laps around a forty-eight (48.7) mile course. The trucks were spaced out approximately one (1) minute to prevent any aerodynamic interaction but be exposed to nearly identical traffic and ambient conditions.

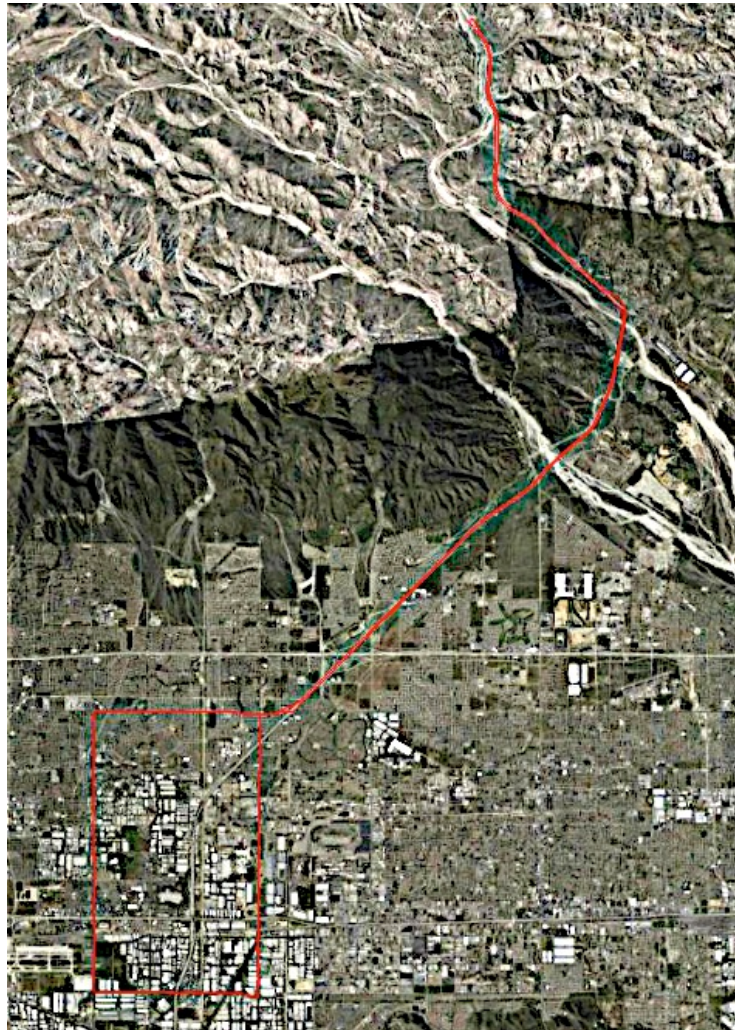
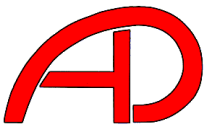


Figure 5. Aerial view of the on-road course used.

## **Methodology**

A test plan was developed for this program based on ATDS standard practices with basic requirements per SAE J1321 Fuel Consumption Test Procedure in combination with SAEJ1264 Fuel Consumption Test Procedure. This procedure consists of fuel consumption measurements for each truck and compared against one another. The difference in fuel consumptions are used to calculate fuel savings percentage presumably resulting from the fuel efficiency of each truck as all trucks were operated under identical operating conditions. For this program, a circuit was defined as two continuous laps consisting of the test route detailed in the previous section.

In preparation for the start of a circuit, each auxiliary fuel tank was filled to maximum capacity and weighed. Once fueled and weighed, the fuel tanks were securely mounted in the box of each truck and the quick-disconnect fuel supply and return lines were re-connected. Figure 6 below depicts the weighing of the fuel tanks and securing



the fuel tank on one of the trucks. The scales used were UWE Model SAC-60C with auto ranging capacities of thirty (30), seventy-five (75), and one-hundred-fifty (150) pounds. The respective accuracy of each capacity is two-thousandths (0.002), five-thousandths (0.005), and one-hundredths (0.01) of a pound. The precision of the scales is  $\frac{1}{70000}$ .



Figure 6. Refueling auxiliary fuel tank (Top Left), weighing auxiliary fuel tank (Top Right), securely mounting and reconnecting auxiliary fuel tank in box of truck (Bottom).

Once all trucks were staged, the drivers conducted a daily inspection of the trucks consisting of engine oil and fluids check, tire pressure check, general vehicle inspection, made sure their respective ballast was in the truck, windows were closed, HVAC set to the assigned setting for that circuit, and confirmed the GPS data loggers were working. Figure 7 on the following page shows the trucks during the daily inspection.

A circuit is officially started when all three trucks are simultaneously started. A fourth person counts down and signals to start engines to accomplish the simultaneous engine start. The first truck is then signaled to begin the route, a one (1) minute wait is





Figure 7. Daily Inspections being performed on the test trucks.

observed, then the second truck is signaled to begin the route, another one (1) minute wait is observed, then the last truck is signaled to begin the route. When the circuit was completed, the trucks would park and idle until all three trucks returned. Once all three trucks were parked the engines were simultaneously shut off using the same count down procedure as the engine start. The pattern for driver and order of the trucks starting the route was the following:

In order from circuit start from top to bottom:		
Circuit 1	Circuit 2	Circuit 3
Driver C w/ 2522-03	Driver C w/ 2522-02	Driver C w/ 2522-01
Driver B w/ 2522-02	Driver B w/ 2522-01	Driver B w/ 2522-03
Driver A w/ 2522-01	Driver A w/ 2522-03	Driver A w/ 2522-02

Following the completion of each circuit, the auxiliary fuel tanks were weighed and the process was repeated beginning with refueling the fuel tanks. Figure 8 shows the pre and post weighing of an auxiliary fuel tank for a circuit. A maximum of two (2) valid



circuits per day were completed. Once five (5) valid circuits were conducted with all three trucks in an identical configuration, 2522-01 Mitsubishi Fuso FE160 was switched to “ECO mode” by toggling a switch on the dash. With 2522-01 in “ECO mode”, five (5) additional valid circuits were conducted using the same procedure detailed above.



Figure 8. Initial auxiliary tank weighing following refuel (Top) and ending auxiliary tank weighing following a circuit run (Bottom).

## Calculations

The following equations and calculations were used for this project:

$$\text{Fuel Consumption (lb)} = \text{AuxTank}_{\text{initial}_i} - \text{AuxTank}_{\text{final}_i} \quad (\text{Eq. 1})$$

Where,

*AuxTank<sub>initial<sub>i</sub></sub>* is the measured weight of the auxiliary fuel tank prior to circuit *i*.

*AuxTank<sub>final<sub>i</sub></sub>* is the measured weight of the auxiliary fuel tank following circuit *i*.



$$Fuel\ Consumption\ (gal) = \frac{Fuel\ Consumption\ (lb)}{7.1\left(\frac{lb}{gal}\right)} \quad (Eq.2)$$

$$Percent\ Difference = \frac{(Veh_A - Veh_B)}{\frac{(Veh_A + Veh_B)}{2}} \times 100 \quad (Eq. 3)$$

Where,

*Veh<sub>x</sub>* is the gallons of fuel consumed for a circuit by vehicle X.

$$Fuel\ Economy\ (mpg) = \frac{Distance_{Circuit\ i}}{Fuel\ Consumption_{Circuit\ i}} \quad (Eq. 4)$$

Where,

*Distance<sub>Circuit, i</sub>* is the distance in miles of circuit i.

*Fuel Consumption<sub>Circuit, i</sub>* is the fuel consumed in gallons of circuit i.

$$Projected\ Savings\ to\ 100k\ miles\ (dollars) = \frac{100,000\ (miles)}{Fuel\ Economy\ (mpg)} \times Diesel_{avg\_price} \left(\frac{dollars}{gal}\right)$$

Where,

*Diesel<sub>avg, price</sub>* is the national average price of diesel per gallon.

## Test Results

### Recorded Data

2522-01 Mitsubishi Fuso FE160									
Driver	Date	Start Time	Start Weight	Start Odometer	End Time	End Weight	End Odometer	Distance (Odometer)	Distance (GPS)
			(lb)	(miles)		(lb)	(miles)	(miles)	(miles)
OG	5/5	11:02	129.6	78	14:11	78.5	175	97	97.9
WS	5/8	6:19	122.5	175	9:25	65.9	272	97	98.0
WS	5/10	6:09	104.2	488	9:13	51.6	585	97	97.9
CM	5/10	10:11	112.1	585	12:55	56.0	682	97	97.8
WS	5/11	6:13	108.5	766	9:19	54.0	863	97	98.0
OG	5/11	10:25	109.6	863	13:23	61.4	960	97	98.0
LO	5/12	6:17	111.5	960	9:11	62.2	1059	99	99.0
WS	5/12	10:06	108.7	1059	13:00	60.7	1156	97	97.8
CM	5/15	6:11	114.1	1156	9:04	60.2	1253	97	97.9
LO	5/15	9:51	102.9	1253	12:52	51.0	1352	99	99.2



**AUTOMOTIVE TESTING AND DEVELOPMENT SERVICES, INC.**

2522-02 Hino 155									
Driver	Date	Start Time	Start Weight	Start Odometer	End Time	End Weight	End Odometer	Distance (Odometer)	Distance (GPS)
			(lb)	(miles)		(lb)	(miles)	(miles)	(miles)
WS	5/5	11:02	120.1	14566	14:11	64.4	14664	98	97.8
CM	5/8	6:19	127.6	14664	9:25	63.2	14762	98	97.9
CM	5/10	6:09	119.9	14957	9:13	63.0	15055	98	97.8
LO	5/10	10:11	120.7	15055	12:55	64.4	15152	97	97.9
OG	5/11	6:13	123.3	15237	9:19	71.5	15334	97	98.1
CM	5/11	10:25	121.5	15334	13:23	66.9	15432	98	97.8
WS	5/12	6:17	117.2	15432	9:11	62.8	15529	97	97.9
CM	5/12	10:06	122.9	15529	13:00	67.4	15627	98	97.8
LO	5/15	6:11	122.1	15627	9:04	65.2	15725	98	97.8
WS	5/15	9:51	116.9	15725	12:52	60.1	15823	98	96.1

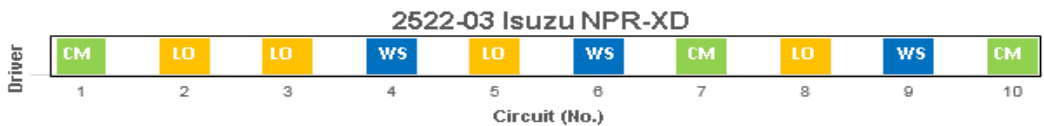
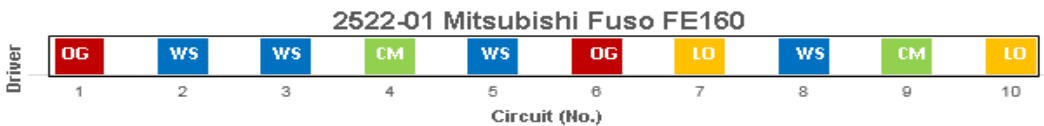
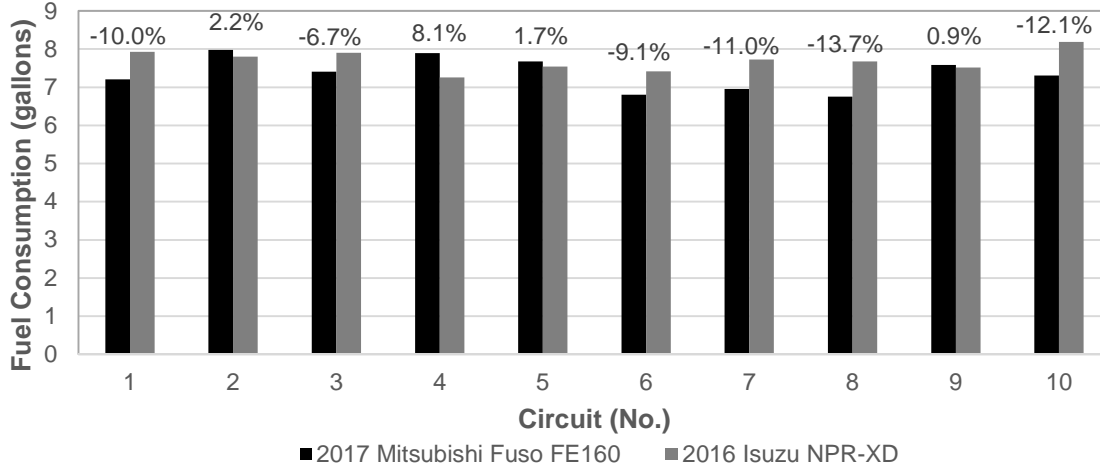
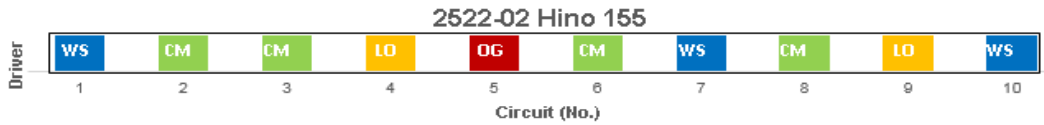
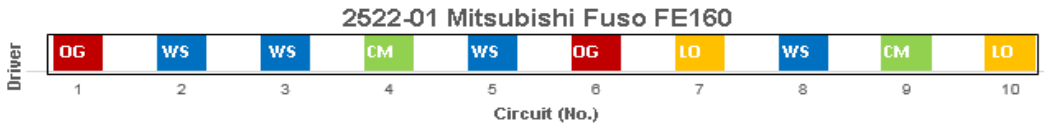
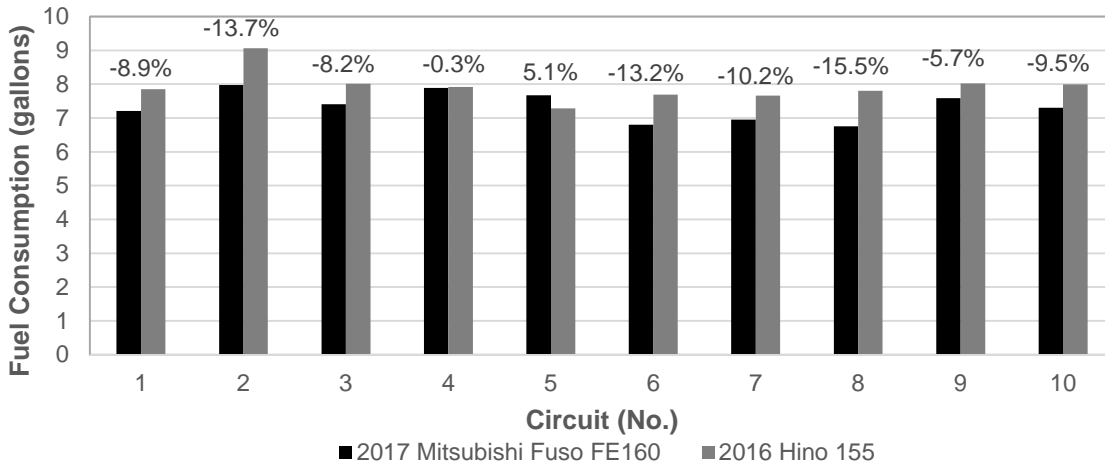
2522-03 Isuzu NPR-XD									
Driver	Date	Start Time	Start Weight	Start Odometer	End Time	End Weight	End Odometer	Distance (Odometer)	Distance (GPS)
			(lb)	(miles)		(lb)	(miles)	(miles)	(miles)
CM	5/5	11:02	109.2	302	14:11	52.9	398	96	97.9
LO	5/8	6:19	108.7	398	9:25	53.3	494	96	97.9
LO	5/10	6:09	108.8	687	9:13	52.7	784	97	97.9
WS	5/10	10:11	111.0	784	12:55	59.5	880	96	97.9
LO	5/11	6:13	104.0	963	9:19	50.4	1059	96	97.9
WS	5/11	10:25	105.7	1059	13:23	53.0	1156	97	97.8
CM	5/12	6:17	113.6	1156	9:11	58.8	1252	96	97.9
LO	5/12	10:06	111.5	1252	13:00	57.0	1349	97	97.9
WS	5/15	6:11	112.5	1349	9:04	59.1	1445	96	97.9
CM	5/15	9:51	109.4	1445	12:52	51.2	1541	96	97.8

**Fuel Consumption**

Fuel Consumption	
2522-01	2017 Mitsubishi Fuso FE160
2522-02	2017 Hino 155
2522-03	2017 Isuzu NPR-XD

Circuit 1	Circuit 2	Circuit 3	Circuit 4	Circuit 5	Circuit 6	Circuit 7	Circuit 8	Circuit 9	Circuit 10
5/5/2017	5/8/2017	5/10/2017	5/10/2017	5/11/2017	5/11/2017	5/12/2017	5/12/2017	5/15/2017	5/15/2017
(gallons of diesel)									
7.21	7.98	7.41	7.89	7.67	6.80	6.95	6.76	7.59	7.31
7.85	9.06	8.01	7.92	7.28	7.70	7.67	7.80	8.02	8.00
7.93	7.80	7.41	7.25	7.55	7.42	7.72	7.68	7.52	8.19

	Total Average	ECO OFF Average	ECO ON Average
<b>2522-01 &amp; 2522-02</b>	-7.5%	-4.9%	-10.1%
<b>2522-01 &amp; 2522-03</b>	-4.5%	-0.7%	-8.5%







**Fuel Economy**

	Circuit 1	Circuit 2	Circuit 3	Circuit 4	Circuit 5	Circuit 6	Circuit 7	Circuit 8	Circuit 9	Circuit 10
	(miles)									
Average GPS Distance	97.87	97.96	97.85	97.83	97.96	97.87	98.24	97.84	97.89	97.70
	(mpg)									
2522-01	13.58	12.28	13.21	12.39	12.77	14.39	14.13	14.48	12.90	13.37
2522-02	12.47	10.81	12.21	12.36	13.45	12.72	12.82	12.54	12.21	12.21
2522-03	12.35	12.56	12.38	13.49	12.98	13.19	12.72	12.74	13.02	11.93

	Total Average	ECO OFF Average	ECO ON Average
	(mpg)		
	13.35	12.85	13.85
	12.38	12.26	12.50
	12.74	12.75	12.72
<b>Percent Difference</b>			
2522-01 & 2522-02	7.6%	4.7%	10.3%
2522-01 & 2522-03	4.7%	0.7%	8.5%

<b>Projected Fuel Cost to 100,000 miles</b>			
Calculated using National Average Price of Diesel \$2.509/gal			
	ECO ON & OFF	ECO OFF	ECO ON
2522-01	\$18,793.19	\$19,530.68	\$18,109.37
2522-02	\$20,270.08	\$20,468.26	\$20,075.71
2522-03	\$19,700.96	\$19,676.07	\$19,725.91
<b>Projected Fuel Savings per 100,000 miles</b>			
2522-01 & 2522-02	\$1,476.9	\$937.6	\$1,966.3
2522-01 & 2522-03	\$907.8	\$145.4	\$1,616.5

**Data Review and Analysis**

Based upon ATDS' review of the test data above, the 2017 Mitsubishi Fuso FE160 appears to be more fuel economical than the 2016 Hino 155 and the 2016 Isuzu NPR-XD. This conclusion is based upon the finding that the fuel consumption of the Fuso Truck was measured to be significantly less than the other two competitive trucks when operated under identical operating, traffic, and ambient conditions. In addition, when projecting the fuel economy calculated in this program to one-hundred-thousand (100,000) miles of operation, the fuel savings of a 2017 Mitsubishi Fuso FE160 as compared to a 2016 Hino 155 and a 2016 Isuzu NPR-XD amounts to approximately \$1,476 and \$907 respectively when operating the Fuso truck fifty (50) percent of the time with "ECO mode" on and fifty (50) percent of the time with "ECO mode" off. If the Fuso truck is operated solely with "ECO mode" on, the fuel savings increase to



## **AUTOMOTIVE TESTING AND DEVELOPMENT SERVICES, INC.**

approximately \$1,966 and \$1,616 for every one-hundred-thousand (100,000) miles of operation as compared to the Hino 155 and Isuzu NPR-XD.

If there are any additional information required, please do not hesitate to call me at the numbers below. It has been a pleasure working with Mitsubishi Fuso Truck of America, Inc. on this program and we look forward to future efforts.

Sincerely,

Oscar Garcia  
Test Engineer