

**PARTIAL
STURAA TEST
7 YEAR
200,000 MILE BUS
from
GLAVAL BUS, DIVISION of FOREST RIVER, INC.
MODEL 26' TITAN II
MAY 2013
PTI-BT-R1304-P**

PENNSTATE



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MECHANICAL TESTING
CERTIFICATE 3172.01

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EXECUTIVE SUMMARY

Glaval Bus, Division of Forest River Inc., submitted a model 26' Titan II, propane-powered ten seat/25.5-foot bus, for a partial STURAA test in the 7 yr. /200,000 mile category. The Federal Transit Administration determined that the following tests would be performed: 4.1 Performance, 4.2 Brake Test, 6. Fuel Economy, 7.1 Interior Noise Tests, 7.2 Exterior Noise Tests and 8. Emissions. Testing started on March 14, 2013 and was completed on May 20, 2013. The Check-In section of the report provides a description of the bus and specifies its major components.

The interior of the bus is configured with seating for 10 passengers including the driver (two seats fold away for two wheelchair positions). Note: as per the manufacturer, this test bus is not designed for standing passengers. At 150 lbs. per person (8) and 600 lbs. per wheelchair position (two), this load results in a measured gross vehicle weight of 12,380 lbs.

Effective January 1, 2010 the Federal Transit Administration determined that the total number of simulated passengers used for loading all test vehicles will be based on the full complement of seats and free-floor space available for standing passengers (150 lbs per passenger). The passenger loading used for dynamic testing will not be reduced in order to comply with Gross Axle Weight Ratings (GAWR's) or the Gross Vehicle Weight Ratings (GVWR's) declared by the manufacturer. Cases where the loading exceeds the GAWR and/or the GVWR will be noted accordingly. During the testing program, all test vehicles transported or operated over public roadways will be loaded to comply with the GAWR and GVWR specified by the manufacturer.

The performance of the bus is illustrated by a speed vs. time plot. Acceleration and gradeability test data are provided in Section 4, Performance. The average time to obtain 50 mph was 13.60 seconds. Top speed as measured on the dynamometer was 82.1 mph. The Stopping Distance phase of the Brake Test was completed with the following results; for the Uniform High Friction Test average stopping distances were 21.91' at 20 mph, 44.35' at 30 mph, 82.09' at 40 mph and 98.95' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 21.68'. There was no deviation from the test lane during the performance of the Stopping Distance phase. During the Stability phase of Brake Testing the test bus experienced no deviation from the test lane but did experience pull to the left during both approaches to the Split Friction Road surface. The Parking Brake phase was completed with the test bus maintaining the parked position for the full five minute period with no slip or roll observed in both the uphill and downhill positions.

A Fuel Economy Test was run on simulated central business district, arterial, and commuter courses. The results were 5.33 mpg, 5.23 mpg, and 8.73 mpg respectively; with an overall average of 5.94 mpg.

A series of Interior and Exterior Noise Tests was performed. These data are listed in Section 7.1 and 7.2 respectively.

The Emissions Test was performed. These results are available in Section 8 of this report.

ABBREVIATIONS

ABTC	- Altoona Bus Test Center
A/C	- air conditioner
ADB	- advance design bus
ATA-MC	- The Maintenance Council of the American Trucking Association
CBD	- central business district
CW	- curb weight (bus weight including maximum fuel, oil, and coolant; but without passengers or driver)
dB(A)	- decibels with reference to 0.0002 microbar as measured on the "A" scale
DIR	- test director
DR	- bus driver
EPA	- Environmental Protection Agency
FFS	- free floor space (floor area available to standees, excluding ingress/egress areas, area under seats, area occupied by feet of seated passengers, and the vestibule area)
GVL	- gross vehicle load (150 lb for every designed passenger seating position, for the driver, and for each 1.5 sq ft of free floor space)
GVW	- gross vehicle weight (curb weight plus gross vehicle load)
GVWR	- gross vehicle weight rating
MECH	- bus mechanic
mpg	- miles per gallon
mph	- miles per hour
PM	- Preventive maintenance
PSBRTF	- Penn State Bus Research and Testing Facility
PTI	- Pennsylvania Transportation Institute
rpm	- revolutions per minute
SAE	- Society of Automotive Engineers
SCH	- test scheduler
SEC	- secretary
SLW	- seated load weight (curb weight plus 150 lb for every designed passenger seating position and for the driver)
STURAA	- Surface Transportation and Uniform Relocation Assistance Act
TD	- test driver
TECH	- test technician
TM	- track manager
TP	- test personnel

TEST BUS CHECK-IN

I. OBJECTIVE

The objective of this task is to log in the test bus, assign a bus number, complete the vehicle data form, and perform a safety check.

II. TEST DESCRIPTION

The test consists of assigning a bus test number to the bus, cleaning the bus, completing the vehicle data form, obtaining any special information and tools from the manufacturer, determining a testing schedule, performing an initial safety check, and performing the manufacturer's recommended preventive maintenance. The bus manufacturer must certify that the bus meets all Federal regulations.

III. DISCUSSION

The check-in procedure is used to identify in detail the major components and configuration of the bus.

The test bus consists of a Glaval Bus, Division of Forest River, Inc., model 26' Titan II. The bus has an OEM driver's door and passenger door rear of the front axle. The dedicated handicap entrance is equipped with a Ricon model RIS5510FF1120701E platform lift located rear of the rear axle and a cargo door is centered at the rear. Power is provided by a propane-fueled, General Motors 6.0 L engine coupled to a GM HD 6-spd automatic transmission.

The measured curb weight is 3,490 lbs for the front axle and 6,530 lbs. for the rear axle. These combined weights provide a total measured curb weight of 10,020 lbs. There are 10 seats including the driver--two seats fold away for two wheelchair positions. Note: as per the manufacturer, this test bus is not designed for standing passengers. Gross load is $150 \text{ lbs.} \times 8 = 1,200 \text{ lbs.} + 1,200 \text{ lbs. (2 wheelchair positions)} = 2,400 \text{ lbs.}$ At full capacity, the measured gross vehicle weight is 12,380 lbs.

VEHICLE DATA FORM

Page 1 of 7

Bus Number: 1304	Arrival Date: 3/14/13
Bus Manufacturer: Glaval	Vehicle Identification Number (VIN): 1G6G5BB1D1129399
Model Number: 26' Titan II	Date: 3/14/13
Personnel: J.P., T.S., E.L., T.S., E.D. & T.G.	Chassis: Chevrolet / G33803

WEIGHT:

Individual Wheel Reactions:

Weights (lb)	Front Axle		Middle Axle		Rear Axle	
	Right	Left	Right	Left	Right	Left
CW	1,780	1,710	N/A	N/A	3,540	2,990
SLW	1,750	2,100	N/A	N/A	4,240	4,290
GVW	1,750	2,100	N/A	N/A	4,240	4,290

Total Weight Details:

Weight (lb)	CW	SLW	GVW	GAWR
Front Axle	3,490	3,850	3,850	4,600
Middle Axle	N/A	N/A	N/A	N/A
Rear Axle	6,530	8,530	8,530	9,600
Total	10,020	12,380	12,380	GVWR: 14,200

Dimensions:

Length (ft/in)	25 / 6.75
Width (in)	97.50
Height (in)	116.75
Front Overhang (in)	39.50
Rear Overhang (in)	89.75
Wheel Base (in)	177.50
Wheel Track (in)	Front: 68.0
	Rear: 74.8

VEHICLE DATA FORM

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Bus Number: 1304	Date: 3/14/13
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CLEARANCES:

Lowest Point Outside Front Axle	Location: Spoiler Clearance(in): 11.0
Lowest Point Outside Rear Axle	Location: Exhaust Clearance(in): 16.3
Lowest Point between Axles	Location: Body Clearance(in): 10.4
Ground Clearance at the center (in)	10.4
Front Approach Angle (deg)	15.5
Rear Approach Angle (deg)	10.2
Ramp Clearance Angle (deg)	6.6
Aisle Width (in)	18.2
Inside Standing Height at Center Aisle (in)	74.7

BODY DETAILS:

Body Structural Type	Integral			
Frame Material	Steel			
Body Material	Steel			
Floor Material	Plywood			
Roof Material	Fiberglass			
Windows Type	☒ Fixed	☒ Movable		
Window Mfg./Model No.	Clear Vision / AS3 DOT 960 Ansi Z26.1-1996			
Number of Doors	2 Front		2 Rear	
Mfr. / Model No.	Driver: GM / OEM	Passenger: A&M Systems/SN: 14428341G4	Wheelchair Lift Door: Glaval Bus / NA	Rear: N/A
Dimension of Each Door (in)	Driver: 29.4 x 56.0	Passenger: 36.0 x 82.5	Wheelchair 44.2 x 70.8	Rear: 33.2 x 62.5
Passenger Seat Type	☐ Cantilever	☒ Pedestal		☐ Other (explain)
Mfr. / Model No.	Freedman / 3-Point, 19" Mid-High			
Driver Seat Type	☐ Air	☒ Spring		☒ Other (explain) Electric
Mfr. / Model No.	USSC / EVOLUTION G2ELP			
Number of Seats (including Driver)	10 or (8 + 2 wheelchair positions)			

VEHICLE DATA FORM

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Bus Number: 1304	Date: 3/14/13
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BODY DETAILS (Continued)

Free Floor Space (ft ²)	30.9
Height of Each Step at Normal Position (in)	Front 1. <u>11.5</u> 2. <u>8.0</u> 3. <u>8.2</u> 4. <u>N/A</u>
	Middle 1. <u>N/A</u> 2. <u>N/A</u> 3. <u>N/A</u> 4. <u>N/A</u>
	Rear 1. <u>N/A</u> 2. <u>N/A</u> 3. <u>N/A</u> 4. <u>N/A</u>
Step Elevation Change - Kneeling (in)	N/A

ENGINE

Type	☐ C.I.	☒ Alternate Fuel	
	☒ S.I.	☐ Other (explain)	
Mfr. / Model No.	G.M. / 6.0L		
Location	☒ Front	☐ Rear	☐ Other (explain)
Fuel Type	☐ Gasoline	☐ CNG	☐ Methanol
	☐ Diesel	☐ LNG	☒ Other Liquid (explain) Propane
Fuel Tank Capacity (gallons)	47.7		
Fuel Induction Type	☒ Injected	☐ Carburetion	
Fuel Injector Mfr. / Model No.	G.M. / 6.0L		
Carburetor Mfr. / Model No.	N/A		
Fuel Pump Mfr. / Model No.	G.M. / 6.0L		
Alternator (Generator) Mfr. / Model No.	Sure Charde Kei Height AMP Alternator/K6V240H1-8		
Maximum Rated Output (Volts / Amps)	12 / 240		
Air Compressor Mfr. / Model No.	N/A		
Maximum Capacity (ft ³ / min)	N/A		
Starter Type	☒ Electrical	☐ Pneumatic	☐ Other (explain)
Starter Mfr. / Model No.	GM / 12637616		

VEHICLE DATA FORM

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TRANSMISSION

Transmission Type	☐ Manual	☒ Automatic	
Mfr. / Model No.	GM / HD 6-spd auto.		
Control Type	☒ Mechanical	☐ Electrical	☐ Other
Torque Converter Mfr. / Model No.	GM / HD 6-spd auto.		
Integral Retarder Mfr. / Model No.	N/A		

SUSPENSION

Number of Axles	2		
Front Axle Type	☒ Independent	☐ Beam Axle	
Mfr. / Model No.	GM / OEM		
Axle Ratio (if driven)	N/A		
Suspension Type	☐ Air	☒ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	GM / OEM		
Middle Axle Type	☐ Independent	☐ Beam Axle	
Mfr. / Model No.	N/A		
Axle Ratio (if driven)	N/A		
Suspension Type	☐ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	N/A		
Mfr. / Model No.	N/A		
Rear Axle Type	☐ Independent	☒ Beam Axle	
Mfr. / Model No.	Dana / OEM		
Axle Ratio (if driven)	4:10		
Suspension Type	☐ Air	☒ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	GM / OEM		

VEHICLE DATA FORM

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Bus Number: 1304	Date: 3/14/13
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WHEELS & TIRES

Front	Wheel Mfr./ Model No.	GM/16 x 6
	Tire Mfr./ Model No.	General LT225/75 R16
Rear	Wheel Mfr./ Model No.	GM/16 x 6
	Tire Mfr./ Model No.	General LT225/75 R16

BRAKES

Front Axle Brakes Type	☐ Cam	☒ Disc	☐ Other (explain)
Mfr. / Model No.	GM / OEM		
Middle Axle Brakes Type	☐ Cam	☐ Disc	☐ Other (explain)
Mfr. / Model No.	N/A		
Rear Axle Brakes Type	☐ Cam	☒ Disc	☐ Other (explain)
Mfr. / Model No.	GM / OEM		
Retarder Type	N/A		
Mfr. / Model No.	N/A		

HVAC

Heating System Type	☐ Air	☒ Water	☐ Other
Capacity (Btu/hr)	50,000		
Mfr. / Model No.	Dash – GM / OEM Cab – OEM #435-50-011-258		
Air Conditioner	☒ Yes	☐ No	
Location	Front roof		
Capacity (Btu/hr)	80,000		
A/C Compressor Mfr. / Model No.	Denso / 11P004807(OEM) / Thermo King 70251B		

STEERING

Steering Gear Box Type	Worm
Mfr. / Model No.	GM / OEM 260B8053
Steering Wheel Diameter	15.3"
Number of turns (lock to lock)	3.25

VEHICLE DATA FORM

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Bus Number: 1304	Date: 3/14/13
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OTHERS

Wheel Chair Ramps	Location: N/A	Type: N/A
Wheel Chair Lifts	Location: Rear of Bus	Type: Fold-out platform
Mfr. / Model No.	Ricon / RIS 5510FF1120701E	
Emergency Exit	Location: Windows Doors Roof Hatch	Number: 2 2 1

CAPACITIES

Fuel Tank Capacity (gallons)	47.7
Engine Crankcase Capacity (gallons)	Not available.
Transmission Capacity (gallons)	Not available.
Differential Capacity (gallons)	Not available.
Cooling System Capacity (quarts)	Not available.
Power Steering Fluid Capacity (quarts)	Not available.

VEHICLE DATA FORM

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Bus Number: 1301	Date: 3/14/13
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List all spare parts, tools and manuals delivered with the bus.

[illegible]

COMPONENT/SUBSYSTEM INSPECTION FORM

Page 1 of 1

Bus Number: 1304	Date: 3/14/13
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Subsystem	Checked	Initials	Comments
Air Conditioning Heating and Ventilation	✓	E.D.	
Body and Sheet Metal	✓	E.D.	
Frame	✓	E.D.	
Steering	✓	E.D.	
Suspension	✓	E.D.	
Interior/Seating	✓	E.D.	
Axles	✓	E.D.	
Brakes	✓	E.D.	
Tires/Wheels	✓	E.D.	
Exhaust	✓	E.D.	
Fuel System	✓	E.D.	
Power Plant	✓	E.D.	
Accessories	✓	E.D.	
Lift System	✓	E.D.	
Interior Fasteners	✓	E.D.	
Batteries	✓	E.D.	

CHECK - IN



**GLAVAL BUS, DIVISION OF FOREST RIVER INC.,
MODEL 26' TITAN II**



CHECK - IN CONT.



**GLAVAL BUS, DIVISION of FOREST RIVER INC.,
MODEL 26' TITAN II EQUIPPED WITH A RICON
MODEL RIS5510FF1120701E HANDICAP LIFT**



CHECK - IN CONT.



VIN TAG



OPERATOR'S AREA

CHECK - IN CONT.



INTERIOR FRONT TO REAR



INTERIOR REAR TO FRONT

CHECK - IN CONT.



FUEL CELLS



4.1 PERFORMANCE - AN ACCELERATION, GRADEABILITY, AND TOP SPEED TEST

4-I. TEST OBJECTIVE

The objective of this test is to determine the acceleration, gradeability, and top speed capabilities of the bus.

4-II. TEST DESCRIPTION

In this test, the bus will be operated at SLW on the skid pad at the PSBRTF. The bus will be accelerated at full throttle from a standstill to a maximum "geared" or "safe" speed as determined by the test driver. The vehicle speed is measured using a Correvit non-contacting speed sensor. The times to reach speed between ten mile per hour increments are measured and recorded using a stopwatch with a lap timer. The time to speed data will be recorded on the Performance Data Form and later used to generate a speed vs. time plot and gradeability calculations.

4-III. DISCUSSION

This test consists of three runs in both the clockwise and counterclockwise directions on the Test Track. Velocity versus time data is obtained for each run and results are averaged together to minimize any test variability which might be introduced by wind or other external factors. The test was performed up to a maximum speed of 50 mph. The fitted curve of velocity vs. time is attached, followed by the calculated gradeability results. The average time to obtain 50 mph was 13.60 seconds. Top speed was 82.1 mph.

PERFORMANCE DATA FORM

Page 1 of 1

Bus Number: 1304		Date: 4-8-13
Personnel: T.S., S.R., B.L. & C.S.		
Temperature (°F): 67		Humidity (%): 41
Wind Direction: SW		Wind Speed (mph): 4
Barometric Pressure (in.Hg): 28.74		
		INITIALS:
Air Conditioning compressor-OFF	✓ Checked	T.S.
Ventilation fans-ON HIGH	✓ Checked	T.S.
Heater pump motor-Off	✓ Checked	T.S.
Defroster-OFF	✓ Checked	T.S.
Exterior and interior lights-ON	✓ Checked	T.S.
Windows and doors-CLOSED	✓ Checked	T.S.

ACCELERATION, GRADEABILITY, TOP SPEED			
Counter Clockwise Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph	2.18	2.06	1.94
20 mph	4.27	4.10	4.21
30 mph	6.76	6.61	6.46
40 mph	9.95	9.75	9.54
Top Test Speed(mph) 50	14.09	13.85	13.89
Clockwise Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph	2.03	1.93	1.96
20 mph	3.91	3.66	4.02
30 mph	6.15	5.70	6.34
40 mph	9.15	8.93	9.40
Top Test Speed(mph) 50	13.56	12.73	13.47

1304.ACC

PERFORMANCE SUMMARY SHEET

BUS MANUFACTURER :GLAVAL
BUS MODEL :TITAN II G33803

BUS NUMBER :1304
TEST DATE :04/08/13

TEST CONDITIONS :

TEMPERATURE (DEG F) : 67.0
WIND DIRECTION : SW
WIND SPEED (MPH) : 4.0
HUMIDITY (%) : 41
BAROMETRIC PRESSURE (IN. HG) : 28.7

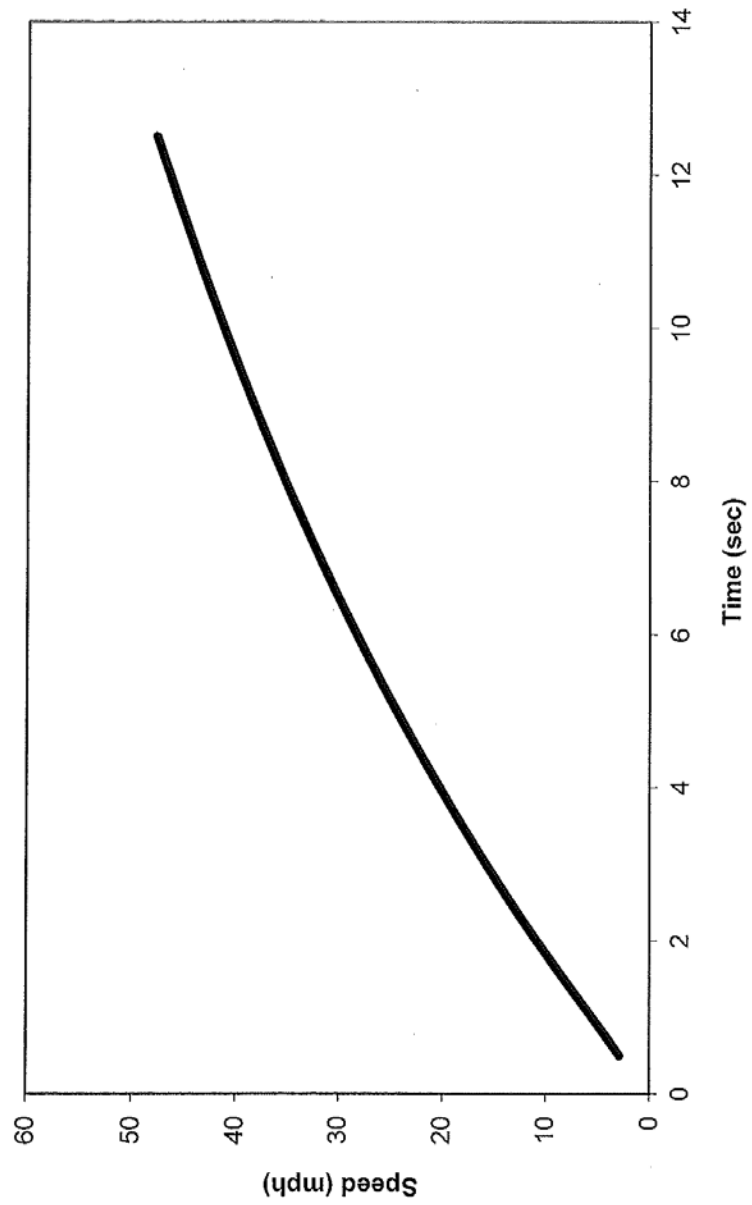
VEHICLE SPEED (MPH)	AVERAGE TIME (SEC)		
	CCW DIRECTION	CW DIRECTION	TOTAL
10.0	2.06	1.97	2.02
20.0	4.19	3.86	4.03
30.0	6.61	6.06	6.34
40.0	9.75	9.16	9.45
50.0	13.94	13.25	13.60

TEST SUMMARY :

VEHICLE SPEED (MPH)	TIME (SEC)	ACCELERATION (FT/SEC^2)	MAX. GRADE (%)
1.0	.17	8.5	27.5
5.0	.88	8.1	25.9
10.0	1.82	7.5	23.9
15.0	2.84	6.9	22.0
20.0	3.94	6.3	20.1
25.0	5.15	5.8	18.3
30.0	6.48	5.3	16.6
35.0	7.95	4.7	14.9
40.0	9.58	4.2	13.3
45.0	11.42	3.8	11.8
50.0	13.49	3.3	10.4

NOTE : Gradeability results were calculated from performance
----- test data. Actual sustained gradeability performance
for vehicles equipped with auto transmission may be
lower than the values indicated here.

Velocity vs. Time
Glaval Bus #1304



4.0 PERFORMANCE

4.2 Performance - Bus Braking

4.2 I. TEST OBJECTIVE

The objective of this test is to provide, for comparison purposes, braking performance data on transit buses produced by different manufacturers.

4.2 II. TEST DESCRIPTION

The testing will be conducted at the PTI Test Track skid pad area. Brake tests will be conducted after completion of the GVW portion of the vehicle durability test. At this point in testing the brakes have been subjected to a large number of braking snubs and will be considered well burnished. Testing will be performed when the bus is fully loaded at its GVW. All tires on each bus must be representative of the tires on the production model vehicle

The brake testing procedure comprises three phases:

1. Stopping distance tests
 - i. Dry surface (high-friction, Skid Number within the range of 70-76)
 - ii. Wet surface (low-friction, Skid Number within the range of 30-36)
2. Stability tests
3. Parking brake test

Stopping Distance Tests

The stopping distance phase will evaluate service brake stops. All stopping distance tests on dry surface will be performed in a straight line and at the speeds of 20, 30, 40 and 45 mph. All stopping distance tests on wet surface will be performed in straight line at speed of 20 mph.

The tests will be conducted as follows:

1. **Uniform High Friction Tests:** Four maximum deceleration straight-line brake applications each at 20, 30, 40 and 45 mph, to a full stop on a uniform high-friction surface in a 3.66-m (12-ft) wide lane.
2. **Uniform Low Friction Tests:** Four maximum deceleration straight-line brake applications from 20 mph on a uniform low friction surface in a 3.66-m (12-ft) wide lane.

When performing service brake stops for both cases, the test vehicle is accelerated on the bus test lane to the speed specified in the test procedure and this speed is maintained into the skid pad area. Upon entry of the appropriate lane of the skid pad area, the vehicle's service brake is applied to stop the vehicle as quickly as possible. The stopping distance is measured and recorded for both cases on the test data form. Stopping distance results on dry and wet surfaces will be recorded and the average of the four measured stopping distances will be considered as the measured stopping distance. Any deviation from the test lane will be recorded.

Stability Tests

This test will be conducted in both directions on the test track. The test consists of four maximum deceleration, straight-line brake applications on a surface with split coefficients of friction (i.e., the wheels on one side run on high-friction SN 70-76 or more and the other side on low-friction [where the lower coefficient of friction should be less than half of the high one] at initial speed of 30 mph).

(I) The performance of the vehicle will be evaluated to determine if it is possible to keep the vehicle within a 3.66m (12 ft) wide lane, with the dividing line between the two surfaces in the lane's center. The steering wheel input angle required to keep the vehicle in the lane during the maneuver will be reported.

Parking Brake Test

The parking brake phase utilizes the brake slope, which has a 20% grade. The test vehicle, at its GVW, is driven onto the brake slope and stopped. With the transmission in neutral, the parking brake is applied and the service brake is released. The test vehicle is required to remain stationary for five minutes. The parking brake test is performed with the vehicle facing uphill and downhill.

4.2-III. DISCUSSION

The Stopping Distance phase of the Brake Test was completed with the following results; for the Uniform High Friction Test average stopping distances were 21.91' at 20 mph, 44.35' at 30 mph, 82.09' at 40 mph and 98.95' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 21.68'. There was no deviation from the test lane during the performance of the Stopping Distance phase.

During the Stability phase of Brake Testing the test bus experienced no deviation from the test lane but did experience pull to the left during both approaches to the Split Friction Road surface.

The Parking Brake phase was completed with the test bus maintaining the parked position for the full five minute period with no slip or roll observed in both the uphill and downhill positions.

Table 4.2-6. Braking Test Data Forms

Page 1 of 3

Bus Number: 1304	Date: 4-9-13
Personnel: B.L., S.R. & J.S.	
Amb. Temperature (°F): 62	Wind Speed (mph): 8
Wind Direction: N	Pavement Temp (°F) Start: 76.3 End: 78.6

TIRE INFLATION PRESSURE (psi):				
Tire Type: Front: General LT 225/75R 16 Rear: General LT 225/75R 16				
	Left Tire(s)		Right Tire(s)	
Front	80		80	
	Inner	Outer	Inner	Outer
Rear	80	80	80	80
Rear	N/A	N/A	N/A	N/A

AXLE LOADS (lb)		
	Left	Right
Front	2,100	1,750
Rear	4,290	4,240

FINAL INSPECTION	
Bus Number: 1304	Date: 4-9-13
Personnel: B.L. & S.R.	

Table 4.2-7. Record of All Braking System Faults/Repairs.

Page 2 of 3

Date	Personnel	Fault/Repair	Description
4/9/13	B.L. & S.R.	None noted.	None noted.

Table 4.2-8.1. Stopping Distance Test Results Form

Page 3 of 3

Stopping Distance (ft)					
Vehicle Direction	CW	CW	CCW	CCW	
Speed (mph)	Stop 1	Stop 2	Stop 3	Stop 4	Average
20 (dry)	21.05	22.42	22.18	21.98	21.91
30 (dry)	44.91	44.69	42.32	45.96	44.35
40 (dry)	81.21	83.03	85.50	78.59	82.09
45 (dry)	98.43	98.73	98.80	99.84	98.95
20 (wet)	22.04	21.52	21.18	21.98	21.68

Table 4.2-8.2. Stability Test Results Form

Stability Test Results (Split Friction Road surface)		
Vehicle Direction	Attempt	Did test bus stay in 12' lane? (Yes/No)
CW	1	Yes
	2	Yes
CCW	1	Yes
	2	Yes

Table 4.2-8.3. Parking Brake Test Form

PARKING BRAKE (Fully Loaded) – GRADE HOLDING						
Vehicle Direction	Attempt	Hold Time (min)	Slide (in)	Roll (in)	Did Hold	No Hold
Front up	1	5			✓	
	2					
	3					
Front down	1	5			✓	
	2					
	3					

6. FUEL ECONOMY TEST - A FUEL CONSUMPTION TEST USING AN APPROPRIATE OPERATING CYCLE

6-I. TEST OBJECTIVE

The objective of this test is to provide accurate comparable fuel consumption data on transit buses produced by different manufacturers. This fuel economy test bears no relation to the calculations done by the Environmental Protection Agency (EPA) to determine levels for the Corporate Average Fuel Economy Program. EPA's calculations are based on tests conducted under laboratory conditions intended to simulate city and highway driving. This fuel economy test, as designated here, is a measurement of the fuel expended by a vehicle traveling a specified test loop under specified operating conditions. The results of this test will not represent actual mileage but will provide data that can be used by recipients to compare buses tested by this procedure.

6-II. TEST DESCRIPTION

This test requires operation of the bus over a course based on the Transit Coach Operating Duty Cycle (ADB Cycle) at seated load weight using a procedure based on the Fuel Economy Measurement Test (Engineering Type) For Trucks and Buses: SAE 1376 July 82. The procedure has been modified by elimination of the control vehicle and by modifications as described below. The inherent uncertainty and expense of utilizing a control vehicle over the operating life of the facility is impractical.

The fuel economy test will be performed as soon as possible (weather permitting) after the completion of the GVW portion of the structural durability test. It will be conducted on the bus test lane at the Penn State Test Facility. Signs are erected at carefully measured points which delineate the test course. A test run will comprise 3 CBD phases, 2 Arterial phases, and 1 Commuter phase. An electronic fuel measuring system will indicate the amount of fuel consumed during each phase of the test. The test runs will be repeated until there are at least two runs in both the clockwise and counterclockwise directions in which the fuel consumed for each run is within ± 4 percent of the average total fuel used over the 4 runs. A 20-minute idle consumption test is performed just prior to and immediately after the driven portion of the fuel economy test. The amount of fuel consumed while operating at normal/low idle is recorded on the Fuel Economy Data Form. This set of four valid runs along with idle consumption data comprise a valid test.

The test procedure is the ADB cycle with the following four modifications:

1. The ADB cycle is structured as a set number of miles in a fixed time in the following order: CBD, Arterial, CBD, Arterial, CBD, and Commuter. A separate idle fuel consumption measurement is performed at the beginning and end of the fuel economy test. This phase sequence permits the reporting of fuel consumption for each of these phases separately, making the data more useful to bus manufacturers and transit properties.
2. The operating profile for testing purposes shall consist of simulated transit type service at seated load weight. The three test phases (figure 6-1) are: a central business district (CBD) phase of 2 miles with 7 stops per mile and a top speed of 20 mph; an arterial phase of 2 miles with 2 stops per mile and a top speed of 40 mph; and a commuter phase of 4 miles with 1 stop and a maximum speed of 40 mph. At each designated stop the bus will remain stationary for seven seconds. During this time, the passenger doors shall be opened and closed.
3. The individual ADB phases remain unaltered with the exception that 1 mile has been changed to 1 lap on the Penn State Test Track. One lap is equal to 5,042 feet. This change is accommodated by adjusting the cruise distance and time.
4. The acceleration profile, for practical purposes and to achieve better repeatability, has been changed to "full throttle acceleration to cruise speed".

Several changes were made to the Fuel Economy Measurement Test (Engineering Type) For Trucks and Buses: SAE 1376 July 82:

1. Sections 1.1, and 1.2 only apply to diesel, gasoline, methanol, and any other fuel in the liquid state (excluding cryogenic fuels).

1.1 SAE 1376 July 82 requires the use of at least a 16-gal fuel tank. Such a fuel tank when full would weigh approximately 160 lb. It is judged that a 12-gal tank weighing approximately 120 lb will be sufficient for this test and much easier for the technician and test personnel to handle.

1.2 SAE 1376 July 82 mentions the use of a mechanical scale or a flow meter system. This test procedure uses a load cell readout combination that provides an accuracy of 0.5 percent in weight and permits on-board weighing of the gravimetric tanks at the end of each phase. This modification permits the determination of a fuel economy value for each phase as well as the overall cycle.

2. Section 2.1 applies to compressed natural gas (CNG), liquefied natural gas (LNG), cryogenic fuels, and other fuels in the vapor state.

2.1 A laminar type flow meter will be used to determine the fuel consumption. The pressure and temperature across the flow element will be monitored by the flow computer. The flow computer will use this data to calculate the gas flow rate. The flow computer will also display the flow rate (scfm) as well as the total fuel used (scf). The total fuel used (scf) for each phase will be recorded on the Fuel Economy Data Form.

3. Use both Sections 1 and 2 for dual fuel systems.

FUEL ECONOMY CALCULATION PROCEDURE

A. For diesel, gasoline, methanol and fuels in the liquid state.

The reported fuel economy is based on the following: measured test quantities-- distance traveled (miles) and fuel consumed (pounds); standard reference values-- density of water at 60°F (8.3373 lbs/gal) and volumetric heating value of standard fuel; and test fuel specific gravity (unitless) and volumetric heating value (BTU/gal). These combine to give a fuel economy in miles per gallon (mpg) which is corrected to a standard gallon of fuel referenced to water at 60°F. This eliminates fluctuations in fuel economy due to fluctuations in fuel quality. This calculation has been programmed into a computer and the data processing is performed automatically.

The fuel economy correction consists of three steps:

- 1.) Divide the number of miles of the phase by the number of pounds of fuel consumed

<u>phase</u>	<u>miles per phase</u>	<u>total miles per run</u>
CBD	1.9097	5.7291
ART	1.9097	3.8193
COM	3.8193	3.8193

$$\mathbf{FEO_{mi/lb}} = \text{Observed fuel economy} = \frac{\text{miles}}{\text{lb of fuel}}$$

- 2.) Convert the observed fuel economy to miles per gallon [mpg] by multiplying by the specific gravity of the test fuel G_s (referred to water) at 60°F and multiply by the density of water at 60°F

$$FE_{\text{mpg}} = FE_{\text{mi/lb}} \times G_s \times G_w$$

where G_s = Specific gravity of test fuel at 60°F (referred to water)
 G_w = 8.3373 lb/gal

- 3.) Correct to a standard gallon of fuel by dividing by the volumetric heating value of the test fuel (H) and multiplying by the volumetric heating value of standard reference fuel (Q). Both heating values must have the same units.

$$FE_c = FE_{\text{mpg}} \times \frac{Q}{H}$$

where

H = Volumetric heating value of test fuel [BTU/gal]
 Q = Volumetric heating value of standard reference fuel

Combining steps 1-3 yields

$$\Rightarrow FE_c = \frac{\text{miles}}{\text{lbs}} \times (G_s \times G_w) \times \frac{Q}{H}$$

- 4.) Convert the fuel economy from mpg to an energy equivalent of miles per BTU. Since the number would be extremely small in magnitude, the energy equivalent will be represented as miles/BTU $\times 10^6$.

Eq = Energy equivalent of converting mpg to mile/BTU $\times 10^6$.

$$Eq = ((\text{mpg})/(H)) \times 10^6$$

B. CNG, LNG, cryogenic and other fuels in the vapor state.

The reported fuel economy is based on the following: measured test quantities--distance traveled (miles) and fuel consumed (scf); density of test fuel, and volumetric heating value (BTU/lb) of test fuel at standard conditions ($P=14.73$ psia and $T=60$ EF). These combine to give a fuel economy in miles per lb. The energy equivalent

(mile/BTUx10⁶) will also be provided so that the results can be compared to buses that use other fuels.

- 1.) Divide the number of miles of the phase by the number of standard cubic feet (scf) of fuel consumed.

phase	miles per phase	total miles per run
CBD	1.9097	5.7291
ART	1.9097	3.8193
COM	3.8193	3.8193

$$\text{FEO}_{\text{mi/scf}} = \text{Observed fuel economy} = \frac{\text{miles}}{\text{scf of fuel}}$$

- 2.) Convert the observed fuel economy to miles per lb by dividing FEO by the density of the test fuel at standard conditions (Lb/ft³).

Note: The density of test fuel must be determined at standard conditions as described above. If the density is not defined at the above standard conditions, then a correction will be needed before the fuel economy can be calculated.

$$\text{FEO}_{\text{mi/lb}} = \text{FEO} / \text{Gm}$$

where Gm = Density of test fuel at standard conditions

- 3.) Convert the observed fuel economy (FEOmi/lb) to an energy equivalent of (miles/BTUx10⁶) by dividing the observed fuel economy (FEOmi/lb) by the heating value of the test fuel at standard conditions.

$$\text{Eq} = ((\text{FEOmi/lb})/\text{H}) \times 10^6$$

where

Eq = Energy equivalent of miles/lb to mile/BTUx10⁶

H = Volumetric heating value of test fuel at standard conditions

6-III. DISCUSSION

This is a comparative test of fuel economy using propane fuel with a heating value 19,904.01 btu/lb. The driving cycle consists of Central Business District (CBD), Arterial (ART), and Commuter (COM) phases as described in 6-II. The fuel consumption for each driving cycle and for idle is measured separately. The results are corrected to a reference fuel with a volumetric heating value of 126,700.0 btu/gal.

An extensive pretest maintenance check is made including the replacement of all lubrication fluids. The details of the pretest maintenance are given in the first three Pretest Maintenance Forms. The fourth sheet shows the Pretest Inspection. The next sheet shows the correction calculation for the test fuel. The next four Fuel Economy Forms provide the data from the four test runs. Finally, the summary sheet provides the average fuel consumption. The overall average is based on total fuel and total mileage for each phase. The overall average fuel consumption values were; CBD – 5.33 mpg, ART – 5.23 mpg, and COM – 8.73 mpg. Average fuel consumption at idle was 1.02 gph.

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

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Bus Number: 1304	Date: 4-23-13	SLW (lbs): 12,380
Personnel: T.S., S.R., B.L., J.P. & E.D.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	✓	4/23/13	B.L.
Replace fuel filter	✓	4/23/13	B.L.
Check for fuel leaks	✓	4/23/13	B.L.
Specify fuel type (refer to fuel analysis)	Propane		
Remarks: None noted.			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	4/23/13	T.S.
Inspect brakes	✓	4/23/13	T.S.
Relube wheel bearings	✓	4/23/13	T.S.
Check tire inflation pressures (mfg. specs.)	✓	4/23/13	T.S.
Remarks: None noted.			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	4/23/13	S.R.
Check system for coolant leaks	✓	4/23/13	S.R.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Page 2 of 3

Bus Number: 1304	Date: 4-23-13		
Personnel: T.S., S.R., B.L., J.P. & E.D.			
ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	4/23/13	E.D.
Inspect wiring	✓	4/23/13	E.D.
Inspect terminals	✓	4/23/13	E.D.
Check lighting	✓	4/23/13	E.D.
Remarks: None noted.			
DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	4/23/13	T.S.
Replace filter/gasket	✓	4/23/13	T.S.
Check hoses and connections	✓	4/23/13	T.S.
Replace transmission fluid	✓	4/23/13	T.S.
Check for fluid leaks	✓	4/23/13	T.S.
Remarks: None noted.			
LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	4/23/13	E.D.
Replace filters	✓	4/23/13	E.D.
Replace crankcase oil	✓	4/23/13	E.D.
Check for oil leaks	✓	4/23/13	E.D.
Check oil level	✓	4/23/13	E.D.
Lube all chassis grease fittings	✓	4/23/13	E.D.
Lube universal joints	✓	4/23/13	E.D.
Replace differential lube including axles	✓	4/23/13	E.D.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

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Bus Number: 1304	Date: 4-23-13		
Personnel: T.S., S.R., B.L., J.P. & E.D.			
EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	✓	4/23/13	S.R.
Remarks: None noted.			
ENGINE	OK	Date	Initials
Replace air filter	✓	4/23/13	S.R.
Inspect air compressor and air system	N/A	4/23/13	S.R.
Inspect vacuum system, if applicable	N/A	4/23/13	S.R.
Check and adjust all drive belts	✓	4/23/13	S.R.
Check cold start assist, if applicable	N/A	4/23/13	S.R.
Remarks: None noted.			
STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors	✓	4/23/13	B.L.
Service fluid level	✓	4/23/13	B.L.
Check power steering operation	✓	4/23/13	B.L.
Remarks: None noted.			
	OK	Date	Initials
Ballast bus to seated load weight	✓	4/23/13	T.S.
TEST DRIVE	OK	Date	Initials
Check brake operation	✓	4/23/13	B.L.
Check transmission operation	✓	4/23/13	B.L.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST INSPECTION FORM

Page 1 of 1

Bus Number:	Date: 4-23-13
Personnel: T.S., S.R., B.L., & J.P.	
PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	T.S.
Cold tire pressure (psi): Front <u>80</u> Middle <u>N/A</u> Rear <u>80</u>	S.R.
Tire wear:	S.R.
Engine oil level	T.S.
Engine coolant level	T.S.
Interior and exterior lights on, evaporator fan on	T.S.
Fuel economy instrumentation installed and working properly.	T.S.
Fuel line -- no leaks or kinks	S.R.
Speed measuring system installed on bus. Speed indicator installed in front of bus and accessible to TECH and Driver.	S.R.
Bus is loaded to SLW	T.S.
WARM-UP	If OK, Initial
Bus driven for at least one hour warm-up	S.R.
No extensive or black smoke from exhaust	S.R.
POST WARM-UP	If OK, Initial
Warm tire pressure (psi): Front <u>83</u> Middle <u>N/A</u> Rear <u>82</u>	S.R.
Environmental conditions Average wind speed <12 mph and maximum gusts <15 mph Ambient temperature between 30°(-1°) and 90°F(32°C) Track surface is dry Track is free of extraneous material and clear of interfering traffic	S.R.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 1 of 4

Bus Number: 1304	Manufacturer: Glaval		Date: 4-25-13	
Run Number: 1	Personnel: T.S., B.L., J.S. & S.R.			
Test Direction: ☐ CW or ☒ CCW	Ambient Temperature (°F): 42	Humidity (%): 61		
SLW (lbs): 12,380	Wind Speed (mph) & Direction: 8 / NW	Barometric Pressure (in.Hg): 28.94		
Cycle Type	Run Time (min:sec)		Fuel Temperature (°F)	Total Fuel Used (Gals)
	Start	Finish		
CBD #1	0	8:34	68.8	0.211
ART #1	0	3:55	70.1	0.282
CBD #2	0	8:31	72.8	0.412
ART #2	0	3:55	75.7	0.412
CBD #3	0	8:33	77.2	0.400
COMMUTER	0	5:57	79.5	0.459
				Total Fuel: 2.176 Gals.
20 minute idle : Total Fuel Used = 0.306 Gals.				
No Load Flow Rate at Idle = N/A Gals.		No Load Flow Rate at Full Throttle = N/A Gals.		
Heating Value = 19,904 BTU/LB				
Comments: None noted.				

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 2 of 4

Bus Number: 1304		Manufacturer: Glaval		Date: 4-25-13	
Run Number: 2		Personnel: T.S., B.L., J.S. & S.R.			
Test Direction: ☒ CW or ☐ CCW		Ambient Temperature (°F): 48		Humidity (%): 49	
SLW (lbs): 12,380		Wind Speed (mph) & Direction: 4 / NW		Barometric Pressure (in.Hg): 29.94	
Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°F)	Total Fuel Used (Gals.)
	Start	Finish		Start	
CBD #1	0	8:36	8:36	69.4	0.330
ART #1	0	3:57	3:57	69.5	0.424
CBD #2	0	8:32	8:32	69.6	0.353
ART #2	0	4:00	4:00	72.1	0.365
CBD #3	0	8:40	8:40	71.4	0.342
COMMUTER	0	5:59	5:59	74.1	0.483
Total Fuel: 2.297 Gals.					
20 minute idle : Total Fuel Used = N/A Gals.					
No Load Flow Rate at Idle = N/A Gals.			No Load Flow Rate at Full Throttle = N/A Gals.		
Heating Value = 19,904 BTU/LB					
Comments: None noted.					

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 3 of 4

Bus Number: 1304	Manufacturer: Glaval		Date: 4-25-13		
Run Number: 3	Personnel: T.S., J.S & S.R.				
Test Direction: ☐ CW or ☒ CCW	Ambient Temperature (°F): 50	Humidity (%): 46			
SLW (lbs): 12,380	Wind Speed (mph) & Direction: 9 / W	Barometric Pressure (in.Hg): 28.93			
Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°F)	Total Fuel Used (Gals.)
	Start	Finish			
CBD #1	0	8:31	8:31	77.7	0.318
ART #1	0	3:53	3:53	80.4	0.353
CBD #2	0	8:24	8:24	80.9	0.389
ART #2	0	3:54	3:54	83.2	0.377
CBD #3	0	8:27	8:27	83.8	0.424
COMMUTER	0	5:56	5:56	85.8	0.377
Total Fuel: 2.238 Gals.					
20 minute idle : Total Fuel Used = N/A Gals.					
No Load Flow Rate at Idle = N/A Gals.			No Load Flow Rate at Full Throttle = N/A Gals.		
Heating Value = 19,904 BTU/LB					
Comments: None noted.					

FUEL ECONOMY DATA FORM (Liquid Fuels)

Page 4 of 4

Bus Number: 1304		Manufacturer: Glaval		Date: 4-25-13	
Run Number: 4		Personnel: T.S., J.S. & S.R.			
Test Direction: ☒ CW or ☐ CCW		Ambient Temperature (°F): 53		Humidity (%): 41	
SLW (lbs): 12,380		Wind Speed (mph) & Direction: 8 / NW		Barometric Pressure (in.Hg): 28.91	
Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°F)	Total Fuel Used (Gals.)
	Start	Finish		Start	
CBD #1	0	8:36	8:36	81.7	0.377
ART #1	0	3:54	3:54	84.1	0.377
CBD #2	0	8:32	8:32	84.4	0.365
ART #2	0	3:56	3:56	86.5	0.342
CBD #3	0	8:33	8:33	86.8	0.389
COMMUTER	0	5:59	5:59	88.3	0.447
Total Fuel: 2.297 Gals					
20 minute idle : Total Fuel Used = 0.377 Gals.					
No Load Flow Rate at Idle = N/A Gals.			No Load Flow Rate at Full Throttle = N/A Gals.		
Heating Value = 19,904 BTU/LB					
Comments: None noted.					

FUEL ECONOMY SUMMARY SHEET

BUS MANUFACTURER : **Glaval** BUS NUMBER: **1304**
 BUS MODEL : **26' Titan II** TEST DATE : 04/25/13

FUEL TYPE : PROPANE
 SP. GRAVITY : .5100
 HEATING VALUE : 19904.00 BTU/Lb
 FUEL TEMPERATURE : 78.10 deg F
 Standard Conditions : 60 deg F and 14.7 psi
 Density of Water : 8.3373 lb/gallon at 60 deg F

CYCLE	TOTAL FUEL USED(GAL)	TOTAL MILES	FUEL ECONOMY MPG(Measured)	FUEL ECONOMY MPG (Corrected)
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Run # :1, CCW

CBD	1.023	5.73	5.601	5.60
ART	.694	3.82	5.504	5.50
COM	.459	3.82	8.322	8.32
TOTAL	2.176	13.37	6.144	6.14

Run # :2, CW

CBD	1.025	5.73	5.590	5.59
ART	.789	3.82	4.842	4.84
COM	.483	3.82	7.909	7.91
TOTAL	2.297	13.37	5.821	5.82

Run # :3, CCW

CBD	1.131	5.73	5.066	5.07
ART	.730	3.82	5.233	5.23
COM	.377	3.82	10.133	10.13
TOTAL	2.238	13.37	5.974	5.97

Run # :4, CW

CBD	1.131	5.73	5.066	5.07
ART	.719	3.82	5.313	5.31
COM	.447	3.82	8.546	8.55
TOTAL	2.297	13.37	5.821	5.82

IDLE CONSUMPTION (MEASURED)

First 20 Minutes Data: .31GAL Last 20 Minutes Data: .38GAL
 Average Idle Consumption: 1.02GAL/Hr

RUN CONSISTENCY: % Difference from overall average of total fuel used

Run 1: 3.4 Run 2: -2.0 Run 3: .6 Run 4: -2.0

SUMMARY (CORRECTED VALUES)

Average Idle Consumption	: 1.02 G/Hr
Average CBD Phase Consumption	: 5.33 MPG
Average Arterial Phase Consumption	: 5.23 MPG
Average Commuter Phase Consumption	: 8.73 MPG
Overall Average Fuel Consumption	: 5.94 MPG
Overall Average Fuel Consumption	: 70.19 Miles/ Million BTU

7. NOISE

7.1 INTERIOR NOISE AND VIBRATION TESTS

7.1-I. TEST OBJECTIVE

The objective of these tests is to measure and record interior noise levels and check for audible vibration under various operating conditions.

7.1-II. TEST DESCRIPTION

During this series of tests, the interior noise level will be measured at several locations with the bus operating under the following three conditions:

1. With the bus stationary, a white noise generating system shall provide a uniform sound pressure level equal to 80 dB(A) on the left, exterior side of the bus. The engine and all accessories will be switched off and all openings including doors and windows will be closed. This test will be performed at the ABTC.
2. The bus accelerating at full throttle from a standing start to 35 mph on a level pavement. All openings will be closed and all accessories will be operating during the test. This test will be performed on the track at the Test Track Facility.
3. The bus will be operated at various speeds from 0 to 55 mph with and without the air conditioning and accessories on. Any audible vibration or rattles will be noted. This test will be performed on the test segment between the Test Track and the Bus Testing Center.

All tests will be performed in an area free from extraneous sound-making sources or reflecting surfaces. The ambient sound level as well as the surrounding weather conditions will be recorded in the test data.

7.1-III. DISCUSSION

This test is performed in three parts. The first part exposes the exterior of the vehicle to 80.0 dB(A) on the left side of the bus and the noise transmitted to the interior is measured. The overall average of the six measurements was 51.3 dB(A); ranging from 49.9 dB(A) in line with the front speaker to 52.5 dB(A) in line with the rear speaker. The interior ambient noise level for this test was 27.1 dB(A).

The second test measures interior noise during acceleration from 0 to 35 mph. This noise level ranged from 72.7 dB(A) at the middle passenger seats to 75.8 dB(A) at the driver's seat. The overall average was 73.8 dB(A). The interior ambient noise level for this test was < 30.0 dB(A).

The third part of the test is to listen for resonant vibrations, rattles, and other noise sources while operating over the road. No vibrations or rattles were noted.

INTERIOR NOISE TEST DATA FORM

Test Condition 1: 80 dB(A) Stationary White Noise

Page 1 of 3

Bus Number: 1304	Date: 3-15-13
Personnel: E.L. & T.G.	
Temperature (°F): 35	Humidity (%): 55
Wind Speed (mph): 4	Wind Direction: SW
Barometric Pressure (in.Hg): 29.89	
Initial Sound Level Meter Calibration: ■ checked by: E.L. & T.G.	
Interior Ambient Noise Level dB(A): 27.1	Exterior Ambient Noise Level dB(A): 47.6
Microphone Height During Testing (in): 29" above seat cushion	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	50.3
Front Passenger Seats	51.6
In Line with Front Speaker	49.9
In Line with Middle Speaker	51.3
In Line with Rear Speaker	52.5
Rear Passenger Seats	52.0

Final Sound Level Meter Calibration: ■ checked by: E.L. & T.G.
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Comments: All readings taken in the center aisle.
Remarks/comments/recommended changes: None noted.
Note: Actual sound level is corrected for ambient inside sound level.

INTERIOR NOISE TEST DATA FORM
Test Condition 2: 0 to 35 mph Acceleration Test

Page 2 of 3

Bus Number: 1304	Date: 4-8-13
Personnel: T.S., S.R., B.L. & C.S.	
Temperature (°F): 67	Humidity (%): 41
Wind Speed (mph): 4	Wind Direction: SW
Barometric Pressure (in.Hg): 28.74	
Initial Sound Level Meter Calibration: ■ checked by: T.S.	
Interior Ambient Noise Level dB(A): < 30.0	Exterior Ambient Noise Level dB(A): 39.8
Microphone Height During Testing (in): 29" from seat cushion.	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	75.8
Front Passenger Seats	73.0
Middle Passenger Seats	72.7
Rear Passenger Seats	73.5

Final Sound Level Meter Calibration: ■ checked by: T.S.

Comments: All readings taken in the center aisle.
Remarks/comments/recommended changes: None noted.
Note: Actual sound level is corrected for ambient inside sound level.

INTERIOR NOISE TEST DATA FORM

Test Condition 3: Audible Vibration Test

Page 3 of 3

Bus Number: 1304	Date: 4-8-13
Personnel: T.S., S.R., B.L. & C.S.	
Temperature (°F): 67	Humidity (%): 41
Wind Speed (mph): 4	Wind Direction: SW
Barometric Pressure (in.Hg): 28.74	

Describe the following possible sources of noise and give the relative location on the bus.

Source of Noise	Location
Engine and Accessories	None
Windows and Doors	None
Seats and Wheel Chair lifts	None

Comment on any other vibration or noise source which may have occurred that is not described above: None noted.
Remarks/comments/recommended changes: None noted.
Note: Actual sound level is corrected for ambient inside sound level.

7.1 INTERIOR NOISE TEST



**TEST BUS SET-UP FOR 80 dB(A)
INTERIOR NOISE TEST**

7.2 EXTERIOR NOISE TESTS

7.2-I. TEST OBJECTIVE

The objective of this test is to record exterior noise levels when a bus is operated under various conditions.

7.2-II. TEST DESCRIPTION

In the exterior noise tests, the bus will be operated at a SLW in three different conditions using a smooth, straight and level roadway:

1. Accelerating at full throttle from a constant speed at or below 35 mph and just prior to transmission upshift.
2. Accelerating at full throttle from standstill.
3. Stationary, with the engine at low idle, high idle, and wide open throttle.

In addition, the buses will be tested with and without the air conditioning and all accessories operating. The exterior noise levels will be recorded.

The test site is at the PSBRTF and the test procedures will be in accordance with SAE Standards SAE J366b, Exterior Sound Level for Heavy Trucks and Buses. The test site is an open space free of large reflecting surfaces. A noise meter placed at a specified location outside the bus will measure the noise level.

During the test, special attention should be paid to:

1. The test site characteristics regarding parked vehicles, signboards, buildings, or other sound-reflecting surfaces
2. Proper usage of all test equipment including set-up and calibration
3. The ambient sound level

7.2-III. DISCUSSION

The Exterior Noise Test determines the noise level generated by the vehicle under different driving conditions and at stationary low and high idle, with and without air conditioning and accessories operating. The test site is a large, level, bituminous paved area with no reflecting surfaces nearby.

With an exterior ambient noise level of 40.3 dB(A), the average test result obtained while accelerating from a constant speed was 75.7 dB(A) on the right side and 74.7 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 41.8 dB(A), the average of the results obtained were 76.8 dB(A) on the right side and 77.1 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 57.4 dB(A) at low idle, 64.7 dB(A) at high idle, and 72.7 dB(A) at wide open throttle. With the accessories and air conditioning off, the readings averaged 11.3 dB(A) lower at low idle, 5.8 dB(A) lower at high idle, and the same 72.7 dB(A) at wide open throttle. The exterior ambient noise level measured during this test was 39.8 dB(A).

EXTERIOR NOISE TEST DATA FORM

Accelerating from Constant Speed

Page 1 of 3

Bus Number: 1304	Date: 4-8-13
Personnel: T.S., S.R., B.L. & C.S.	
Temperature (°F): 70	Humidity (%): 43
Wind Speed (mph): 6	Wind Direction: WSW
Barometric Pressure (in.Hg): 28.70	
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: T.S	
Initial Sound Level Meter Calibration: ■ checked by: T.S.	
Exterior Ambient Noise Level dB(A): 40.3	

Accelerating from Constant Speed Curb (Right) Side		Accelerating from Constant Speed Street (Left) Side	
Run #	Measured Noise Level dB(A)	Run #	Measured Noise Level dB(A)
1	74.6	1	73.8
2	74.2	2	74.6
3	74.9	3	74.8
4	75.9	4	74.1
5	75.4	5	73.9
Average of two highest actual noise levels = 75.7 dB(A)		Average of two highest actual noise levels = 74.7 dB(A)	
Final Sound Level Meter Calibration Check: ■ checked by: T.S.			
Remarks/comments/recommended changes: None noted.			

EXTERIOR NOISE TEST DATA FORM

Accelerating from Standstill

Page 2 of 3

Bus Number: 1304	Date: 4-8-13
Personnel: T.S., S.R., B.L. & C.S.	
Temperature (°F): 70	Humidity (%): 43
Wind Speed (mph): 6	Wind Direction: WSW
Barometric Pressure (in.Hg): 28.70	
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: T.S.	
Initial Sound Level Meter Calibration: ■ checked by: T.S.	
Exterior Ambient Noise Level dB(A): 41.8	

Accelerating from Standstill Curb (Right) Side		Accelerating from Standstill Street (Left) Side	
Run #	Measured Noise Level dB(A)	Run #	Measured Noise Level dB(A)
1	76.4	1	76.2
2	77.1	2	75.8
3	76.4	3	75.3
4	76.0	4	76.5
5	75.5	5	77.6
Average of two highest actual noise levels = 76.8 dB(A)		Average of two highest actual noise levels = 77.1 dB(A)	

Final Sound Level Meter Calibration Check: ■ checked by: T.S.
Remarks/comments/recommended changes: None noted.

EXTERIOR NOISE TEST DATA FORM

Stationary

Page 3 of 3

Bus Number: 1304		Date: 4-8-13	
Personnel: T.S., S.R., B.L. & C.S.			
Temperature (°F): 70		Humidity (%): 43	
Wind Speed (mph): 6		Wind Direction: WSW	
Barometric Pressure (in.Hg): 28.70			
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: T.S.			
Initial Sound Level Meter Calibration: ■ checked by: T.S.			
Exterior Ambient Noise Level dB(A): 39.8			
Accessories and Air Conditioning ON			
Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	500	57.5	57.3
High Idle	1,400	64.8	64.6
Wide Open Throttle	3,900	73.0	72.3
Accessories and Air Conditioning OFF			
Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	500	48.4	43.7
High Idle	1,400	56.9	60.9
Wide Open Throttle	3,900	73.3	72.0
Final Sound Level Meter Calibration Check: ■ checked by: T.S.			
Remarks/comments/recommended changes: None noted.			

7.2 EXTERIOR NOISE TESTS



TEST BUS UNDERGOING EXTERIOR NOISE TESTING



8. EMISSIONS TEST – DYNAMOMETER-BASED EMISSIONS TEST USING TRANSIT DRIVING CYCLES

8-I. TEST OBJECTIVE

The objective of this test is to provide comparable emissions data on transit buses produced by different manufacturers. This chassis-based emissions test bears no relation to engine certification testing performed for compliance with the Environmental Protection Agency (EPA) regulation. EPA's certification tests are performed using an engine dynamometer operating under the Federal Test Protocol. This emissions test is a measurement of the gaseous engine emissions CO, CO₂, NO_x, HC and particulates (diesel vehicles) produced by a vehicle operating on a large-roll chassis dynamometer. The test is performed for three differed driving cycles intended to simulate a range of transit operating environments. The cycles consist of Manhattan Cycle, the Orange County Bus driving cycle, and the Urban Dynamometer Driving Cycle (UDDS). The test is performed under laboratory conditions in compliance with EPA 1065 and SAE J2711. The results of this test may not represent actual in-service vehicle emissions but will provide data that can be used by recipients to compare buses tested under different operating conditions.

8-II. TEST DESCRIPTION

This test is performed in the emissions bay of the LTI Vehicle Testing Laboratory. The Laboratory is equipped with a Schenk Pegasus 300 HP, large-roll (72 inch diameter) chassis dynamometer suitable for heavy-vehicle emissions testing. The dynamometer is located in the end test bay and is adjacent to the control room and emissions analysis area. The emissions laboratory provides capability for testing heavy-duty diesel and alternative-fueled buses for a variety of tailpipe emissions including particulate matter, oxides of nitrogen, carbon monoxide, carbon dioxide, and hydrocarbons. It is equipped with a Horiba full-scale CVS dilution tunnel and emissions sampling system. The system includes Horiba Mexa 7400 Series gas analyzers and a Horiba HF47 Particulate Sampling System. Test operation is automated using Horiba CDTCS software. The computer controlled dynamometer is capable of simulating over-the-road operation for a variety of vehicles and driving cycles.

The emissions test will be performed as soon as permissible after the completion of the GVW portion of the structural durability test. The driving cycles are the Manhattan cycle, a low average speed, highly transient urban cycle (Figure 1), the Orange County Bus Cycle which consists of urban and highway driving segments (Figure 2), and the EPA UDDS Cycle (Figure 3). An emissions test will comprise of two runs for the three

different driving cycles, and the average value will be reported. Test results reported will include the average grams per mile value for each of the gaseous emissions for gasoline buses, for all the three driving cycles. In addition, the particulate matter emissions are included for diesel buses, and non-methane hydrocarbon emissions (NMHC) are included for CNG buses. Testing is performed in accordance with EPA CFR49, Part 1065 and SAE J2711 as practically determined by the FTA Emissions Testing Protocol developed by West Virginia University and Penn State University.

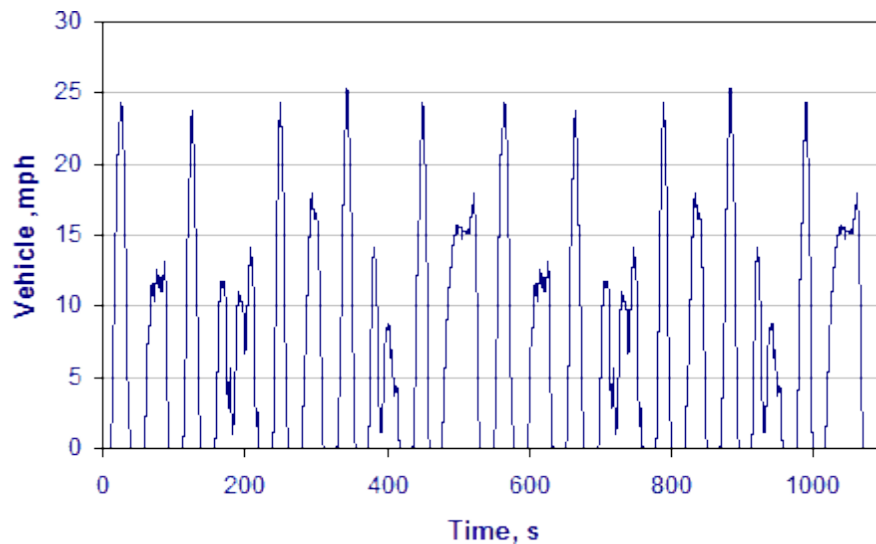


Figure 1. *Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4mph, average speed 6.8mph)*

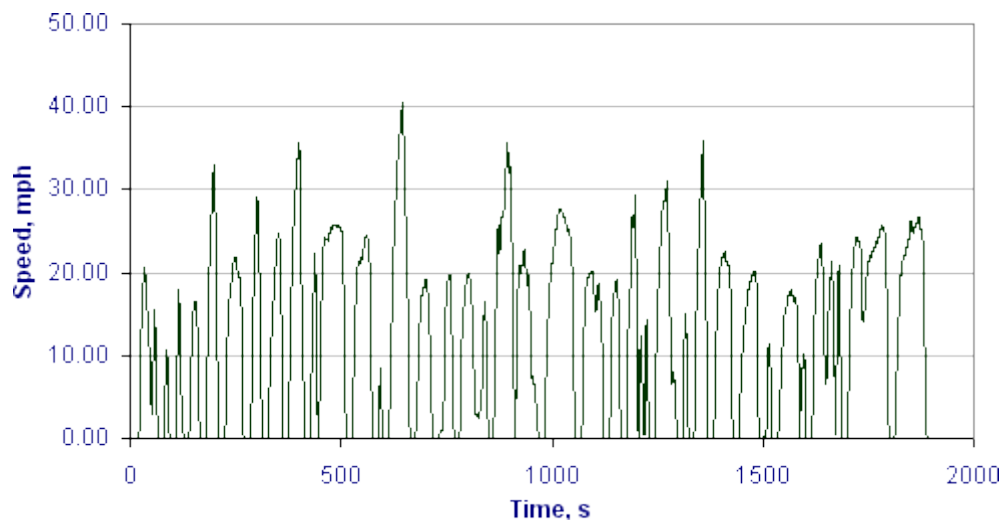


Figure 2. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41mph, Average Speed 12mph)

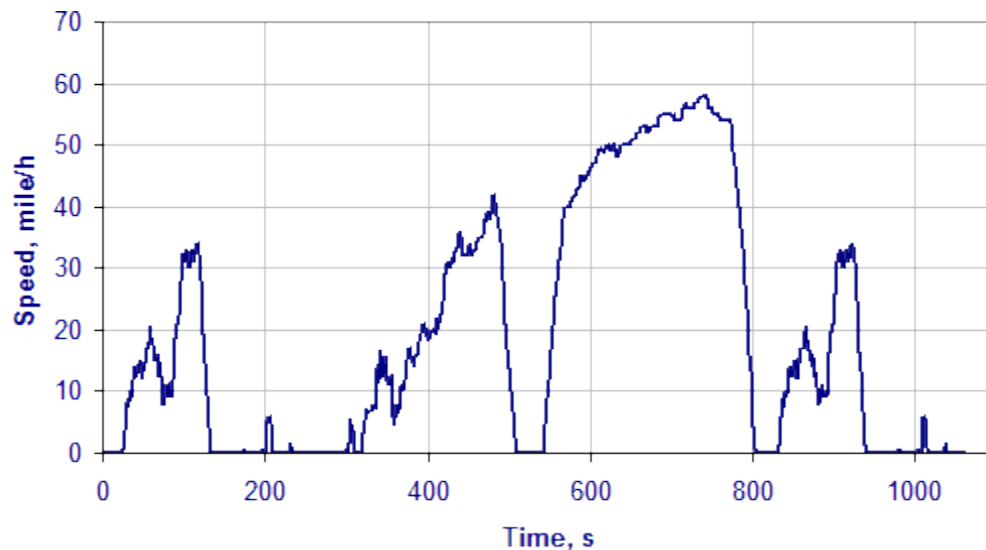


Figure 3. HD-UDDS Cycle (duration 1060seconds, Maximum Speed 58mph, Average Speed 18.86mph)

8-III. TEST ARTICLE

The test article is a Glaval Bus, Division of Forest River, Inc., model 26' Titan II model transit bus equipped with a propane-fueled General Motors 6.0 L engine. The bus was tested on May 13, 2013.

8-IV. TEST EQUIPMENT

Testing is performed in the LTI Vehicle Testing Laboratory emissions testing bay. The test bay is equipped with a Schenk Pegasus 72-inch, large-roll chassis dynamometer. The dynamometer is electronically controlled to account for vehicle road-load characteristics and for simulating the inertia characteristics of the vehicle. Power to the roller is supplied and absorbed through an electronically controlled 3-phase ac motor. Absorbed power is dumped back onto the electrical grid.

Vehicle exhaust is collected by a Horiba CVS, full-flow dilution tunnel. The system has separate tunnels for diesel and gasoline/natural gas fueled vehicles. In the case of diesel vehicles, particulate emissions are measured gravimetrically using 47mm Teflon

filters. These filters are housed in a Horiba HF47 particulate sampler, per EPA 1065 test procedures.. Heated gaseous emissions of hydrocarbons and NO_x are sampled by Horiba heated oven analyzers. Gaseous emissions for CO, CO₂ and cold NO_x are measured using a Horiba Mexa 7400 series gas analyzer. System operation, including the operation of the chassis dynamometer, and all calculations are controlled by a Dell workstation running Horiba CDCTS test control software. Particulate Filters are weighed in a glove box using a Sartorius microbalance accurate to 1 microgram.

8-V. TEST PREPARATION AND PROCEDURES

All vehicles are prepared for emissions testing in accordance with the Fuel Economy Pre-Test Maintenance Form. (In the event that fuel economy test was performed immediately prior to emissions testing this step does not have to be repeated) This is done to ensure that the bus is tested in optimum operating condition. The manufacturer-specified preventive maintenance shall be performed before this test. The ABS system and when applicable, the regenerative braking system are disabled for operation on the chassis dynamometer. Any manufacturer-recommended changes to the pre-test maintenance procedure must be noted on the revision sheet. The Fuel Economy Pre-Test Inspection Form will also be completed before performing. Both the Fuel Economy Pre-Test Maintenance Form and the Fuel Economy Pre-Test Inspection Form are found on the following pages.

Prior to performing the emissions test, each bus is evaluated to determine its road-load characteristics using coast-down techniques in accordance with SAE J1263. This data is used to program the chassis dynamometer to accurately simulate over-the-road operation of the bus.

Warm-up consists of driving the bus for 20 minutes at approximately 40 mph on the chassis dynamometer. The test driver follows the prescribed driving cycle watching the speed trace and instructions on the Horiba Drivers-Aid monitor which is placed in front of the windshield. The CDCTS computer monitors driver performance and reports any errors that could potentially invalidate the test.

All buses are tested at half seated load weight. The base line emissions data are obtained at the following conditions:

1. Air conditioning off
2. Evaporator fan or ventilation fan on
3. One Half Seated load weight
4. Appropriate test fuel with energy content (BTU/LB) noted in CDTCS software
5. Exterior and interior lights on
6. Heater Pump Motor off
7. Defroster off

8. Windows and Doors closed

The test tanks or the bus fuel tank(s) will be filled prior to the fuel economy test with the appropriate grade of test fuel.

8-VI DISCUSSION

The following Table 1 provides the emissions testing results on a grams per mile basis for each of the exhaust constituents measured and for each driving cycle performed.

TABLE 1 Emissions Test Results

Driving Cycle	Manhattan	Orange County Bus	UDDS
CO₂, gm/mi	1,694	1,161	1,059
CO, gm/mi	1.12	0.42	0.88
THC, gm/mi	0.06	0.02	0.09
NMHC, gm/mi	0.006	0.02	0.05
NO_x, gm/mi	0.005	0.001	0.02
Particulates. gm/mi	N/A	N/A	N/A
Fuel consumption mpg	3.32	4.92	5.39

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM

Page 1 of 3

Bus Number: 1304	Date: 4-23-13	SLW (lbs): 12,380
Personnel: T.S., S.R., B.L., J.P. & E.D.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	✓	4/23/13	B.L.
Replace fuel filter	✓	4/23/13	B.L.
Check for fuel leaks	✓	4/23/13	B.L.
Specify fuel type (refer to fuel analysis)	Propane		
Remarks: None noted.			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	4/23/13	T.S.
Inspect brakes	✓	4/23/13	T.S.
Relube wheel bearings	✓	4/23/13	T.S.
Check tire inflation pressures (mfg. specs.)	✓	4/23/13	T.S.
Remarks: None noted.			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	4/23/13	S.R.
Check system for coolant leaks	✓	4/23/13	S.R.
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM

Page 2 of 3

Bus Number: 1304	Date: 4-23-13		
Personnel: T.S., S.R., B.L., J.P. & E.D.			
ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	4/23/13	E.D.
Inspect wiring	✓	4/23/13	E.D.
Inspect terminals	✓	4/23/13	E.D.
Check lighting	✓	4/23/13	E.D.
Remarks: None noted.			
DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	4/23/13	T.S.
Replace filter/gasket	✓	4/23/13	T.S.
Check hoses and connections	✓	4/23/13	T.S.
Replace transmission fluid	✓	4/23/13	T.S.
Check for fluid leaks	✓	4/23/13	T.S.
Remarks: None noted.			
LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	4/23/13	E.D.
Replace filters	✓	4/23/13	E.D.
Replace crankcase oil	✓	4/23/13	E.D.
Check for oil leaks	✓	4/23/13	E.D.
Check oil level	✓	4/23/13	E.D.
Lube all chassis grease fittings	✓	4/23/13	E.D.
Lube universal joints	✓	4/23/13	E.D.
Replace differential lube including axles	✓	4/23/13	E.D.
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM

Page 3 of 3

Bus Number: 1304	Date: 4-23-13		
Personnel: T.S., S.R., B.L., J.P. & E.D.			
EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	✓	4/23/13	S.R.
Remarks: None noted.			
ENGINE	OK	Date	Initials
Replace air filter	✓	4/23/13	S.R.
Inspect air compressor and air system	N/A	4/23/13	S.R.
Inspect vacuum system, if applicable	N/A	4/23/13	S.R.
Check and adjust all drive belts	✓	4/23/13	S.R.
Check cold start assist, if applicable	N/A	4/23/13	S.R.
Remarks: None noted.			
STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors	✓	4/23/13	B.L.
Service fluid level	✓	4/23/13	B.L.
Check power steering operation	✓	4/23/13	B.L.
Remarks: None noted.			
	OK	Date	Initials
Ballast bus to seated load weight	✓	4/23/13	T.S.
TEST DRIVE	OK	Date	Initials
Check brake operation	✓	4/23/13	B.L.
Check transmission operation	✓	4/23/13	B.L.
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST INSPECTION FORM

Page 1 of 1

Bus Number:	Date: 4-23-13
Personnel: T.S., S.R., B.L., & J.P.	
PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	T.S.
Cold tire pressure (psi): Front <u>80</u> Middle <u>N/A</u> Rear <u>80</u>	S.R.
Tire wear:	S.R.
Engine oil level	T.S.
Engine coolant level	T.S.
Interior and exterior lights on, evaporator fan on	T.S.
Fuel economy instrumentation installed and working properly.	T.S.
Fuel line -- no leaks or kinks	S.R.
Speed measuring system installed on bus. Speed indicator installed in front of bus and accessible to TECH and Driver.	S.R.
Bus is loaded to SLW	T.S.
WARM-UP	If OK, Initial
Bus driven for at least one hour warm-up	S.R.
No extensive or black smoke from exhaust	S.R.
POST WARM-UP	If OK, Initial
Warm tire pressure (psi): Front <u>83</u> Middle <u>N/A</u> Rear <u>82</u>	S.R.
Environmental conditions Average wind speed <12 mph and maximum gusts <15 mph Ambient temperature between 30°(-1°) and 90°F(32°C) Track surface is dry Track is free of extraneous material and clear of interfering traffic	S.R.