FEDERAL TRANSIT BUS TEST

Performed for the Federal Transit Administration U.S. DOT
In accordance with CFR 49, Volume 7, Part 665

Manufacturer: New Flyer of America
Model: XN40

Submitted for Partial Testing in Service-Life Category
12 Year / 500,000 Miles

Report Number: LTI-BT-R1403-P

PENNSTATE

1855

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ACCREDITED
Mechanical Testing Certificate 3172.01

Quality Authorization	Director, Bus Research and Testing Center *Title*	7/25/14 *Date*

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EXECUTIVE SUMMARY

New Flyer of America submitted a model XN40, CNG-powered 39 seat/41-foot bus, for a partial STURAA test in the 12 yr./500,000 mile category. The Federal Transit Administration determined that the following tests would be performed: 4.1 Performance, 6. Fuel Economy, 7. Noise Tests and 8. Emissions. Testing started on May 5, 2014 and was completed on June 27, 2014. 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 39 passengers including the driver. Free floor space will accommodate 32 standing passengers resulting in a potential load of 71 persons. At 150 lbs per person, this load results in a measured gross vehicle weight of 43,060 lbs. Note; at gross vehicle weight the front axle is 350 lbs. over the front GAWR, the rear axle is 170 lbs. over the rear GAWR and combined axles are 520 lbs. over the GVWR.

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 36.19 seconds. Top speed obtained on the dynamometer was 57 mph.

A Fuel Economy Test was run on simulated central business district, arterial, and commuter courses. The results were 0.53 M/lb, 0.84 M/lb, and 1.07 M/lb respectively; with an overall average of 0.71 M/lb.

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
PSTT - Penn State Test Track
PTI - Pennsylvania Transportation Institute
rpm - revolutions per minute
SAE - Society of Automotive Engineers
SCH - test scheduler
SA - staff assistant
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 New Flyer of America model XN40. The bus has a front door equipped with a New Flyer model Xcelsior II fold-out handicap ramp forward of the front axle and a rear door forward of the rear axle. Power is provided by a CNG-fueled, Cummins model ISL-G 8.9 L 280 Hp engine coupled to an Allison B400R transmission.

The measured curb weight is 10,770 lbs for the front axle and 21,500 lbs. for the rear axle. These combined weights provide a total measured curb weight of 32,270 lbs. There are 39 seats including the driver and room for 32 standing passengers bringing the total passenger capacity to 71. Gross load is 150 lb x 71 = 10,650 lbs. At full capacity, the measured gross vehicle weight is 43,060 lbs. Note; at gross vehicle weight the front axle is 350 lbs. over the front GAWR, the rear axle is 170 lbs. over the rear GAWR and combined axles are 520 lbs. over the GVWR.

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.

VEHICLE DATA FORM

Bus Number: 1403	Arrival Date: 5-5-14
Bus Manufacturer: New Flyer of America, Inc.	Vehicle Identification Number (VIN): 5FYC8FB10DB042872
Model Number: XN40	Date: 5-5-14
Personnel: T.S. & E.D.	Chassis: New Flyer of America, Inc.

WEIGHT:

Individual Wheel Reactions:

Weights (lb)	Front Axle		Middle Axle		Rear Axle	
	Right	Left	Right	Left	Right	Left
CW	5,400	5,370	N/A	N/A	10,120	11,380
SLW	6,280	6,280	N/A	N/A	11,890	13,890
GVW	7,550	7,580	N/A	N/A	13,140	14,790

Total Weight Details:

Weight (lb)	CW	SLW	GVW	GAWR
Front Axle	10,770	12,560	15,130	14,780
Middle Axle	N/A	N/A	N/A	N/A
Rear Axle	21,500	25,780	27,930	27,760
Total	32,270	38,340	43,060	GVWR: 42,540

Dimensions:

Length (ft/in)	41 / 0
Width (in)	102.0
Height (in)	133.5
Front Overhang (in)	87.75
Rear Overhang (in)	121.75
Wheel Base (in)	283.5
Wheel Track (in)	Front: 85.9
	Rear: 74.2

Bus Number: 1403	Date: 5-5-14

CLEARANCES:

Lowest Point Outside Front Axle	Location: Skid Plate	Clearance(in): 9.9
Lowest Point Outside Rear Axle	Location: Battery Box Frame	Clearance(in): 11.3
Lowest Point between Axles	Location: Frame	Clearance(in): 10.3
Ground Clearance at the center (in)	11.2	
Front Approach Angle (deg)	8.0	
Rear Approach Angle (deg)	8.6	
Ramp Clearance Angle (deg)	4.2	
Aisle Width (in)	Front: 24.4	Rear: 24.1
Inside Standing Height at Center Aisle (in)	Front: 95.2	Rear: 79.5

BODY DETAILS:

Body Structural Type	Semi-Monocoque		
Frame Material	Steel		
Body Material	Composite		
Floor Material	Composite		
Roof Material	Composite		
Windows Type	☑ Fixed Bottom	☑ Movable Top	
Window Mfg./Model No.	Trulite / DOT 798		
Number of Doors	1 Front	1 Rear	
Mfr. / Model No.	Vapor Bus International / Electric		
Dimension of Each Door (in)	Front- 33.9 x 77.9	Rear- 30.6 x 77.5	
Passenger Seat Type	☑ Cantilever	☑ Pedestal	☐ Other (explain)
Mfr. / Model No.	4ONE / Aries		
Driver Seat Type	☑ Air	☐ Spring	☐ Other (explain)
Mfr. / Model No.	USSC / Q91		
Number of Seats (including Driver)	39 or 33 with 2 Wheelchair Positions		

Bus Number: 1403	Date: 5-5-14

BODY DETAILS (Contd..)

Free Floor Space (ft^2)	53.2	
Height of Each Step at Normal Position (in)	Front 1. 13.5 2. N/A 3. N/A 4. N/A	
	Middle 1. N/A 2. N/A 3. N/A 4. N/A	
	Rear 1. 14.0 2. N/A 3. N/A 4. N/A	
Step Elevation Change - Kneeling (in)	Front: 5.0 Change	Rear: 1.2 Change

ENGINE

Type	☐ C.I.	☐ Alternate Fuel	
	☑ S.I.	☐ Other (explain)	
Mfr. / Model No.	Cummins / ISL-G 8.9L 280hp @ 2200 rpm		
Location	☐ Front	☑ Rear	☐ Other (explain)
Fuel Type	☐ Gasoline	☑ CNG	☐ Methanol
	☐ Diesel	☐ LNG	☐ Other (explain)
Fuel Tank Capacity (indicate units)	23,065 Scf @ 3,600 psig @ 70°F		
Fuel Induction Type	☑ Injected	☐ Carburetion	
Fuel Injector Mfr. / Model No.	Cummins / ISL-G 8.9L		
Carburetor Mfr. / Model No.	N/A		
Fuel Pump Mfr. / Model No.	Cummins / ISL-G 8.9L		
Alternator (Generator) Mfr. / Model No.	EMP / Power 450		
Maximum Rated Output (Volts / Amps)	28V / 450 amps		
Air Compressor Mfr. / Model No.	Wabco / 5286681		
Maximum Capacity (ft^3 / min)	30.4		
Starter Type	☑ Electrical	☐ Pneumatic	☐ Other (explain)
Starter Mfr. / Model No.	Delco Remy / 1990413		

TRANSMISSION

Transmission Type	☐ Manual	☑ Automatic	
Mfr. / Model No.	Allison / B400R		
Control Type	☐ Mechanical	☑ Electrical	☐ Other
Torque Converter Mfr. / Model No.	Allison / B400R		
Integral Retarder Mfr. / Model No.	Allison / B400R		

SUSPENSION

Number of Axles	2		
Front Axle Type	☐ Independent	☑ Beam Axle	
Mfr. / Model No.	MAN / VOK-07-F		
Axle Ratio (if driven)	N/A		
Suspension Type	☑ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	KONI / 90 25175P1		
Middle Axle Type	☐ Independent	☐ Beam Axle	☑ N/A
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.	MAN / AGGHY135OF7		
Axle Ratio (if driven)	5.66		
Suspension Type	☑ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	4		
Mfr. / Model No.	KONI / 90 25186P1		

Bus Number: 1403	Date: 5-5-14

WHEELS & TIRES

Front	Wheel Mfr./ Model No.	Accuride 22.5 x 8.25
	Tire Mfr./ Model No.	Goodyear Metro Miler B305/ 70R 22.5
Rear	Wheel Mfr./ Model No.	Accuride 22.5 x 8.25
	Tire Mfr./ Model No.	Goodyear Metro Miler B305/ 70R 22.5

BRAKES

Front Axle Brakes Type	☐ Cam	☑ Disc	☐ Other (explain)
Mfr. / Model No.	Knorr / SN7000		
Middle Axle Brakes Type	☐ Cam	☐ Disc	☑ N/A
Mfr. / Model No.	N/A		
Rear Axle Brakes Type	☐ Cam	☑ Disc	☐ Other (explain)
Mfr. / Model No.	Knorr / SN7000		
Retarder Type	Integral		
Mfr. / Model No.	Allison / B400R		

HVAC

Heating System Type	☐ Air	☑ Water	☐ Other
Capacity (Btu/hr)	94,000		
Mfr. / Model No.	Thermo King / TEA15		
Air Conditioner	☑ Yes	☐ No	
Location	Rear		
Capacity (Btu/hr)	81,000		
A/C Compressor Mfr. / Model No.	Thermo King Corporation / 3000200836 120V 81amps		

STEERING

Steering Gear Box Type	Hydraulic gear
Mfr. / Model No.	RH Sheppard Co. / M110
Steering Wheel Diameter	18.1”
Number of turns (lock to lock)	4 1/2

Bus Number: 1403	Date: 5-5-14

OTHERS

Wheel Chair Ramps	Location: Front	Type: Fold Out
Wheel Chair Lifts	Location: N/A	Type:
Mfr. / Model No.	New Flyer / Xcelsior II	
Emergency Exit	Location: Doors: Windows: Roof Hatches:	Number: 2 4 2

CAPACITIES

Fuel Tank Capacity (units)	23,065 Scf @ 3,600 psi 70° F
Engine Crankcase Capacity (gallons)	6.0
Transmission Capacity (gallons)	7.75
Differential Capacity (gallons)	3.83
Cooling System Capacity (quarts)	7.0
Power Steering Fluid Capacity (quarts)	44.0

OTHERS

CNG Fuel Tanks Mfr. / Model No.	Lincoln Composites (7 tanks)
High Voltage A/C/ Generator Mfr. / Model No.	Copeland-Scroll / ZR48K5E-TFD-130

VEHICLE DATA FORM

Bus Number: 1403	Date: 5-5-14

List all spare parts, tools and manuals delivered with the bus.

Part Number	Description	Qty.
	None noted	

COMPONENT/SUBSYSTEM INSPECTION FORM

Bus Number: 1403	Date: 5-5-14

Subsystem	Checked	Initials	Comments
Air Conditioning Heating and Ventilation	✓	T.S.	
Body and Sheet Metal	✓	T.S.	
Frame	✓	T.S.	
Steering	✓	T.S.	
Suspension	✓	T.S.	
Interior/Seating	✓	T.S.	
Axles	✓	T.S.	
Brakes	✓	T.S.	
Tires/Wheels	✓	T.S.	
Exhaust	✓	T.S.	
Fuel System	✓	T.S.	
Power Plant	✓	T.S.	
Accessories	✓	T.S.	
Lift System	✓	T.S.	
Interior Fasteners	✓	T.S.	
Batteries	✓	T.S.	

CHECK - IN



NEW FLYER of AMERICA
MODEL XN40



CHECK - IN CONT.



NEW FLYER of AMERICA
MODEL XN40 EQUIPPED WITH A
NEW FLYER MODEL XCELSIOR II HANDICAP RAMP



CHECK - IN CONT.



VIN TAG



OPERATOR'S AREA

CHECK - IN CONT.

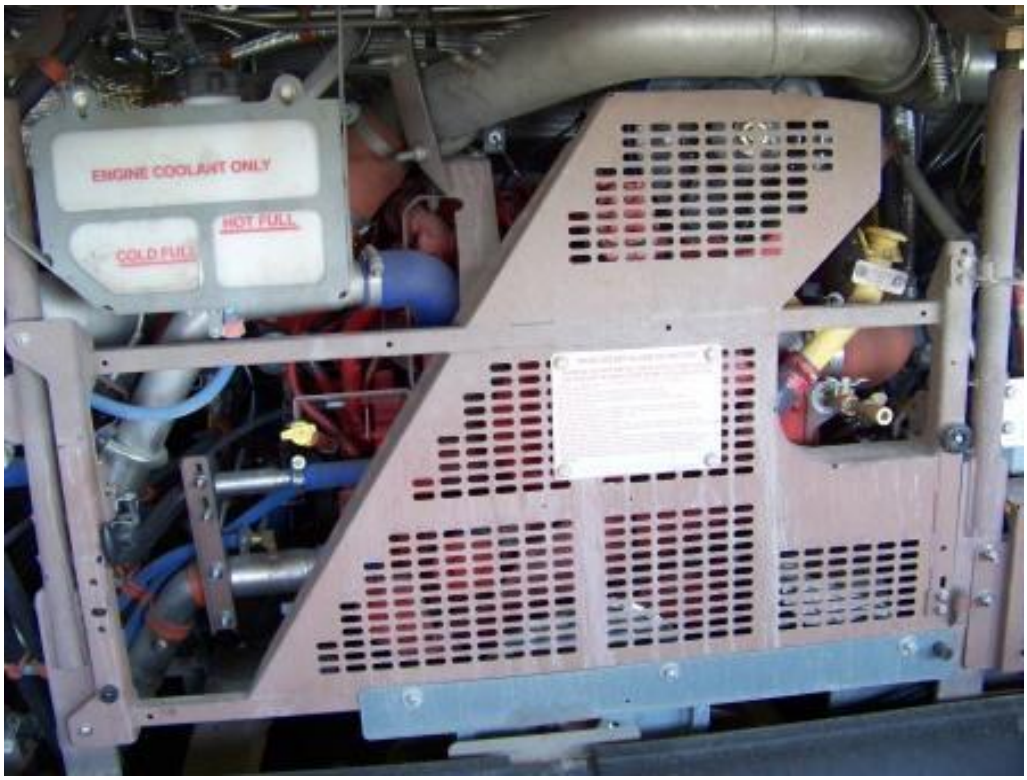


INTERIOR VIEW FRONT-TO-REAR

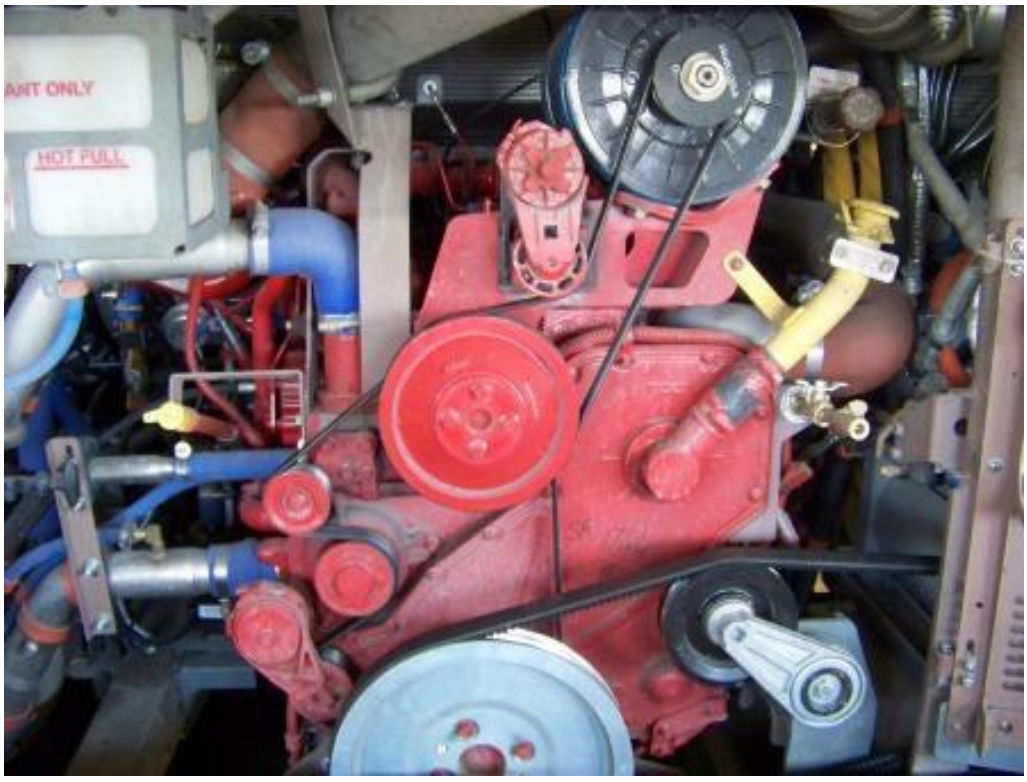


INTERIOR VIEW REAR-TO-FRONT

CHECK - IN CONT.



ENGINE COMPARTMENT



CHECK - IN CONT.



7 ROOF-MOUNTED CNG TANKS



THERMO KING AIR CONDITIONING UNIT

CHECK - IN CONT.



UNDERCARRIAGE FORWARD



UNDERCARRIAGE REAR

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 Penn State 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 36.19 seconds. Top speed obtained on the dynamometer was 57 mph.

PERFORMANCE DATA FORM

Bus Number: 1403	Date: 6-25-14
Personnel: T.S., S.R. & R.S.	
Temperature (°F): 78	Humidity (%): 66
Wind Direction: SSW	Wind Speed (mph): 2
Barometric Pressure (in.Hg): 29.66	

		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	3.89	4.06	4.01
20 mph	7.27	7.41	7.16
30 mph	12.94	13.15	12.53
40 mph	22.27	23.50	22.03
Top Test Speed(mph) 50	37.32	36.97	36.01

Clockwise Recorded Interval Times

Speed	Run 1	Run 2	Run 3
10 mph	3.90	3.90	3.89
20 mph	7.20	6.81	6.96
30 mph	11.97	12.03	12.00
40 mph	20.71	20.78	21.41
Top Test Speed(mph) 50	33.32	34.21	39.28

PERFORMANCE SUMMARY SHEET

BUS MANUFACTURER :New Flyer
BUS MODEL :XN40
BUS NUMBER :1403
TEST DATE :06-25-14

TEST CONDITIONS :

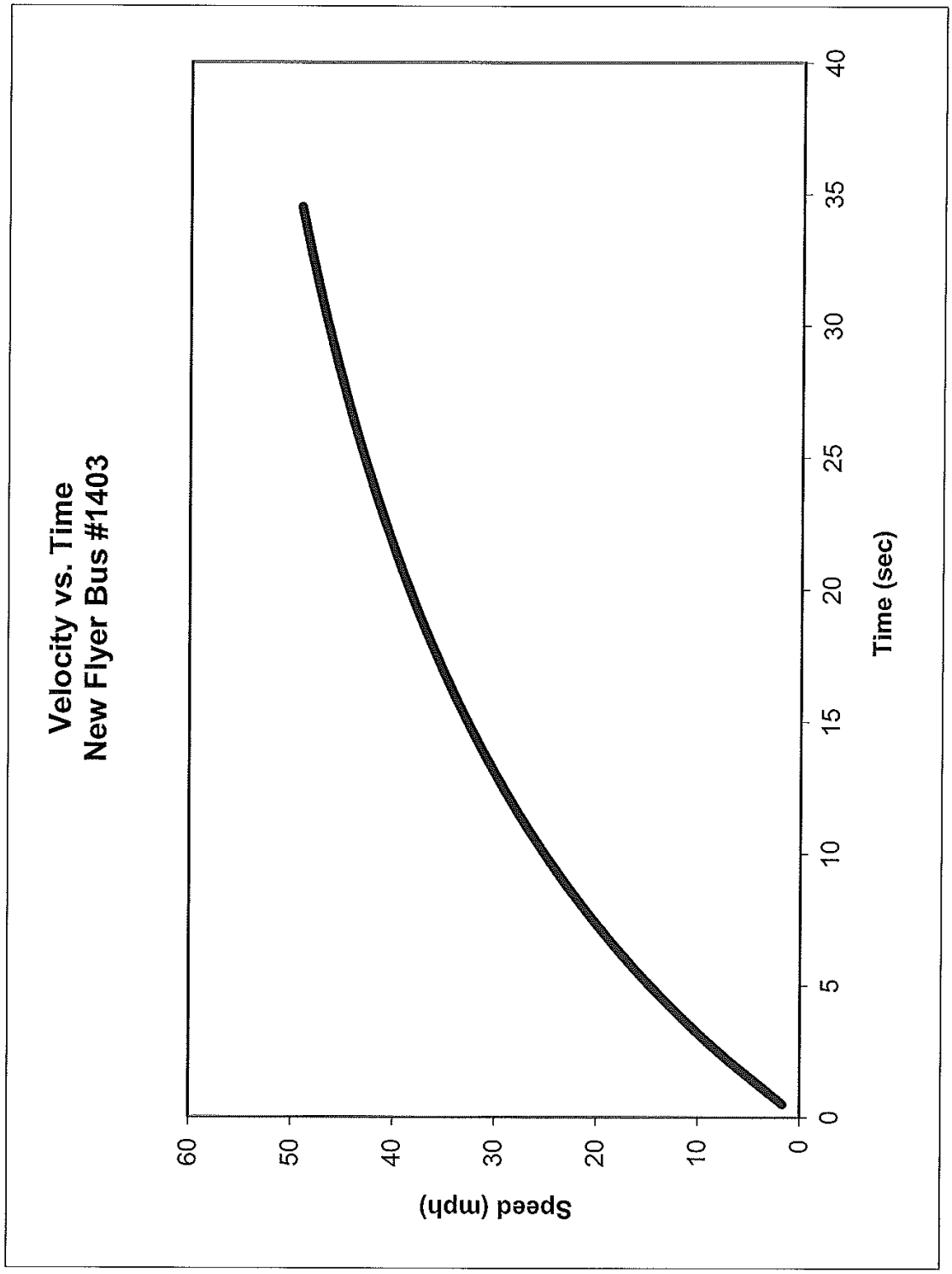
TEMPERATURE (DEG F) : 78.0
WIND DIRECTION : SSW
WIND SPEED (MPH) : 2.0
HUMIDITY (%) : 66
BAROMETRIC PRESSURE (IN. HG) : 29.7

VEHICLE SPEED	AVERAGE TIME (SEC)		
(MPH)	CCW DIRECTION	CW DIRECTION	TOTAL
10.0	3.99	3.90	3.94
20.0	7.28	6.99	7.14
30.0	12.87	12.00	12.44
40.0	22.60	20.97	21.78
50.0	36.77	35.60	36.19

TEST SUMMARY :

VEHICLE SPEED (MPH)	TIME (SEC)	ACCELERATION (FT/SEC^2)	MAX. GRADE (%)
1.0	.29	5.1	15.9
5.0	1.50	4.6	14.5
10.0	3.18	4.1	12.8
15.0	5.10	3.6	11.1
20.0	7.32	3.1	9.6
25.0	9.93	2.6	8.1
30.0	13.03	2.1	6.7
35.0	16.82	1.7	5.4
40.0	21.57	1.4	4.3
45.0	27.73	1.0	3.2
50.0	36.13	.7	2.3

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
New Flyer Bus #1403
Speed (mph)
0
10
20
30
40
50
60
Time (sec)
0
5
10
15
20
25
30
35
40

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

phase	miles per phase	total miles per run
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 Gs (referred to water) at 60°F and multiply by the density of water at 60°F

$$\mathbf{FEo_{mpg}} = \mathbf{FEc_{mi/lb}} \times Gs \times Gw$$

where **Gs** = Specific gravity of test fuel at 60°F (referred to water)
Gw = 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.

$$\mathbf{FEc} = \mathbf{FEo_{mpg}} \times \frac{Q}{H}$$

where

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

Combining steps 1-3 yields

$$\Rightarrow \quad FEc = \frac{\text{miles}}{\text{lbs}} \times (Gs \times Gw) \times \frac{Q}{H}$$

4.) Covert 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/BTUx10^6.

Eq = Energy equivalent of converting mpg to mile/BTUx10^6.

$$Eq = ((mpg)/(H))x10^6$$

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/BTUx10^6) 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

$FEo_{mi/scf}$ = 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/ft^3).

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.

$$FEo_{mi/lb} = FEo / Gm$$

where Gm = Density of test fuel at standard conditions

3.) Convert the observed fuel economy (FEomi/lb) to an energy equivalent of (miles/BTUx10^6) by dividing the observed fuel economy (FEomi/lb) by the heating value of the test fuel at standard conditions.

$$Eq = ((FEomi/lb)/H)x10^6$$

where

Eq = Energy equivalent of miles/lb to mile/BTUx10^6
H = Volumetric heating value of test fuel at standard conditions

6-III. DISCUSSION

This is a comparative test of fuel economy using CNG fuel with a heating value of 1,008.1 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 – 0.53 M/lb, ART – 0.84 M/lb, and COM – 1.07 M/lb. Average fuel consumption at idle was 12.18 lb/hr.

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1403	Date: 6-5-14	SLW (lbs.): 38,340
Personnel: S.R., T.G. & R.S.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	✓	6-2-14	S.R.
Replace fuel filter	✓	5-15-14	E.D.
Check for fuel leaks	✓	6-2-14	S.R.
Specify fuel type (refer to fuel analysis)	CNG		
Remarks: None noted.			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	6-5-14	S.R.
Inspect brakes	✓	6-5-14	S.R.
Relube wheel bearings	✓	6-5-14	S.R.
Check tire inflation pressures (mfg. specs.)	✓	6-5-14	S.R.
Remarks: None noted.			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	6-5-14	S.R.
Check system for coolant leaks	✓	6-5-14	S.R.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1403	Date: 6-5-14
Personnel: S.R., T.G. & R.S.	

ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	6-5-14	T.G.
Inspect wiring	✓	6-5-14	T.G.
Inspect terminals	✓	6-5-14	T.G.
Check lighting	✓	6-5-14	T.G.
Remarks: None noted.			

DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	5-15-14	E.D.
Replace filter/gasket	✓	5-15-14	E.D.
Check hoses and connections	✓	6-5-14	T.G.
Replace transmission fluid	✓	5-15-14	E.D.
Check for fluid leaks	✓	6-5-14	T.G.
Remarks: None noted.			

LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	5-15-14	E.D.
Replace filters	✓	5-15-14	E.D.
Replace crankcase oil	✓	5-15-14	E.D.
Check for oil leaks	✓	6-5-14	T.G.
Check oil level	✓	6-5-14	T.G.
Lube all chassis grease fittings	✓	6-5-14	T.G.
Lube universal joints	✓	6-5-14	T.G.
Replace differential lube including axles			
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1403	Date: 6-5-14
Personnel: S.R., T.G. & R.S.	

EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	✓	6-5-14	T.G.
Remarks: None noted.			
ENGINE	**OK**	**Date**	**Initials**
Replace air filter	✓	5-15-14	E.D.
Inspect air compressor and air system	✓	6-5-14	T.G.
Inspect vacuum system, if applicable	**N/A**	6-5-14	R.R.
Check and adjust all drive belts	✓	6-5-14	T.G.
Check cold start assist, if applicable	✓	6-5-14	T.G.
Remarks: None noted.			
STEERING SYSTEM	**OK**	**Date**	**Initials**
Check power steering hoses and connectors	✓	6-5-14	T.G.
Service fluid level	✓	6-5-14	T.G.
Check power steering operation	✓	6-5-14	T.G.
Replace transmission fluid	✓	5-15-14	E.D.
Remarks: None noted.			
	OK	**Date**	**Initials**
Ballast bus to seated load weight	✓	6-5-14	S.R.
TEST DRIVE	**OK**	**Date**	**Initials**
Check brake operation	✓	6-5-14	T.G.
Check transmission operation	✓	6-5-14	T.G.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST INSPECTION FORM

Bus Number: 1403	Date: 6-5-14
Personnel: S.R., T.G. & R.S.	

PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	S.R.
Cold tire pressure (psi): Front 120 Middle N/A Rear 118	S.R.
Tire wear: less than 50%	S.R.
Engine oil level	S.R.
Engine coolant level	S.R.
Interior and exterior lights on, evaporator fan on	S.R.
Fuel economy instrumentation installed and working properly.	S.R.
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	S.R.
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 122 Middle N/A Rear 120	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 (Gaseous Fuels)

Bus Number: 1403	Manufacturer: New Flyer	Date: 6-5-14
Run Number: 1	Personnel: S.R., T.G. & R.S.	
Test Direction: ☐CW or ☑CCW	Ambient Temperature (°F): 63	Humidity (%): 77
SLW (lbs): 38,340	Wind Speed (mph) & Direction: 6 NW	Barometric Pressure (in.Hg): 29.78

Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°F)	Total Fuel Used (SCF)
	Start	Finish		Start	
CBD #1	0	8:23	8:23	85	94
ART #1	0	3:56	3:56	87	56
CBD #2	0	8:26	8:26	92	86
ART #2	0	3:58	3:58	88	54
CBD #3	0	8:28	8:28	90	87
COMMUTER	0	5:58	5:58	89	84
					Total Fuel: 461 SCF

20 minute idle : Total Fuel Used = 73 SCF	
No Load Flow Rate at Idle = 5.54 SCFM	No Load Flow Rate at Full Throttle = 15.64 SCFM
Heating Value = 1,008.1 BTU/LB	
Comments: None noted.	

FUEL ECONOMY DATA FORM (Gaseous Fuels)

Bus Number: 1403	Manufacturer: New Flyer	Date: 6-5-14
Run Number: 2	Personnel: S.R., T.G. & R.S.	
Test Direction: ☑ CW or ☐CCW	Ambient Temperature (°F): 66	Humidity (%): 55
SLW (lbs): 38,340	Wind Speed (mph) & Direction: 6 WNW	Barometric Pressure (in.Hg): 29.78

Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°F)	Total Fuel Used (SCF)
	Start	Finish		Start	
CBD #1	0	8:40	8:40	92	86
ART #1	0	3:55	3:55	94	56
CBD #2	0	8:43	8:43	95	86
ART #2	0	4:03	4:03	94	56
CBD #3	0	8:45	8:45	96	87
COMMUTER	0	5:58	5:58	94	85
					Total Fuel: 456 SCF

20 minute idle : Total Fuel Used = N/A	
No Load Flow Rate at Idle = N/A	No Load Flow Rate at Full Throttle = N/A
Heating Value = 1,008.1 BTU/LB	
Remarks/comments/recommended changes: None noted.	

FUEL ECONOMY DATA FORM (Gaseous Fuels)

Bus Number: 1403	Manufacturer: New Flyer	Date: 6-5-14
Run Number: 3	Personnel: S.R., T.G. & R.S.	
Test Direction: ☐CW or ☑CCW	Ambient Temperature (°F): 70	Humidity (%): 45
SLW (lbs): 38,340	Wind Speed (mph) & Direction:10 NNW	Barometric Pressure (in.Hg): 29.78

Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°F)	Total Fuel Used (SCF)
	Start	Finish		Start	
CBD #1	0	8:40	8:40	93	89
ART #1	0	4:02	4:02	96	53
CBD #2	0	8:37	8:37	99	88
ART #2	0	4:02	4:02	96	57
CBD #3	0	8:46	8:46	98	94
COMMUTER	0	5:55	5:55	98	92
					Total Fuel: 473 SCF

20 minute idle : Total Fuel Used = N/A	
No Load Flow Rate at Idle = N/A	No Load Flow Rate at Full Throttle = N/A
Heating Value = 1,008.1 BTU/LB	
Remarks/comments/recommended changes: None noted.	

FUEL ECONOMY DATA FORM (Gaseous Fuels)

Bus Number: 1403	Manufacturer: New Flyer	Date: 6-5-14
Run Number: 4	Personnel: S.R., T.G. & R.S.	
Test Direction: ☑CW or ☐CCW	Ambient Temperature (°F): 72	Humidity (%): 42
SLW (lbs): 38,340	Wind Speed (mph) & Direction:11 WNW	Barometric Pressure (in.Hg): 29.78

Cycle Type	Run Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°F)	Total Fuel Used (SCF)
	Start	Finish		Start	
CBD #1	0	8:42	8:42	96	90
ART #1	0	4:04	4:04	97	59
CBD #2	0	8:44	8:44	100	90
ART #2	0	4:03	4:03	98	57
CBD #3	0	8:41	8:41	100	91
COMMUTER	0	5:59	5:59	98	90
					Total Fuel: 477 SCF

20 minute idle : Total Fuel Used = 70 SCF	
No Load Flow Rate at Idle = 4.94 SCFM	No Load Flow Rate at Full Throttle = 14.68 SCFM
Heating Value = 1,008.1 BTU/LB	
Remarks/comments/recommended changes: None noted.	

FUEL ECONOMY SUMMARY SHEET

BUS MANUFACTURER : **New Flyer** BUS NUMBER: **1403**
BUS MODEL : **XN40** TEST DATE : 06/05/14
FUEL TYPE : **NATURAL GAS**
SP. GRAVITY : .5570
HEATING VALUE : 1008.10 BTU/cf
FUEL TEMPERATURE : 94.40 deg F
Standard Conditions: 60 deg F and 14.7 psi
Density of Air : 0.0729 lb/scf

CYCLE	TOTAL FUEL USED (Scf)	TOTAL MILES	FUEL ECONOMY M/Scf(Measured)	FUEL ECONOMY M/Lb(Corrected)
Run # :1, CCW				
CBD	267.0	5.73	.02	.53
ART	110.0	3.82	.03	.86
COM	84.0	3.82	.05	1.12
TOTAL	461.0	13.37	.03	.71
Run # :2, CW				
CBD	259.0	5.73	.02	.54
ART	112.0	3.82	.03	.84
COM	85.0	3.82	.04	1.11
TOTAL	456.0	13.37	.03	.72
Run # :3, CCW				
CBD	271.0	5.73	.02	.52
ART	110.0	3.82	.03	.86
COM	92.0	3.82	.04	1.02
TOTAL	473.0	13.37	.03	.70
Run # :4, CW				
CBD	271.0	5.73	.02	.52
ART	116.0	3.82	.03	.81
COM	90.0	3.82	.04	1.05
TOTAL	477.0	13.37	.03	.69

IDLE CONSUMPTION (MEASURED)

First 20 Minutes Data: **** Scf Last 20 Minutes Data: 97.0 Scf
Average Idle Consumption: 300.0 Scf/Hr

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

Run 1: 1.2 Run 2: 2.3 Run 3: -1.3 Run 4: -2.2

SUMMARY (CORRECTED VALUES)

Average Idle Consumption : 12.18 LB/Hr
Average CBD Phase Consumption : .53 M/Lb
Average Arterial Phase Consumption: .84 M/Lb
Average Commuter Phase Consumption: 1.07 M/Lb
Overall Average Fuel Consumption : .71 M/Lb
Overáll Average Fuel Consumption : 28.42 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 45.4 dB(A); ranging from 43.4 dB(A) at the rear passenger seats to 46.1 dB(A) at the front passenger seats. The interior ambient noise level for this test was < 30.0 dB(A).

The second test measures interior noise during acceleration from 0 to 35 mph. This noise level ranged from 71.7 dB(A) at the driver's seat to 75.8 dB(A) at the rear passenger seats. The overall average was 73.3 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. Squeaking was noted coming from the signage above the right side wheelchair positon.

INTERIOR NOISE TEST DATA FORM
Test Condition 1: 80 dB(A) Stationary White Noise

Bus Number: 1403	Date: 5-5-14
Personnel: T.S. & E.D.	
Temperature (°F): 46	Humidity (%): 71
Wind Speed (mph): < 12 mph	Wind Direction: SW
Barometric Pressure (in.Hg): 28.94	
Initial Sound Level Meter Calibration: 93.6 dB(A): checked by: T.S.	
Interior Ambient Noise Level dB(A): < 30.0	Exterior Ambient Noise Level dB(A): 40.5
Microphone Height During Testing (in): 29” from seat cushion.	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	45.6
Front Passenger Seats	46.1
In Line with Front Speaker	45.9
In Line with Middle Speaker	45.7
In Line with Rear Speaker	45.9
Rear Passenger Seats	43.4

Final Sound Level Meter Calibration: dB(A): 93.6 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 2: 0 to 35 mph Acceleration Test

Bus Number: 1403	Date: 6-25-14
Personnel: T.S., S.R. & R.S.	
Temperature (°F): 80	Humidity (%): 73
Wind Speed (mph): < 12 mph	Wind Direction: S
Barometric Pressure (in.Hg): 29.04	
Initial Sound Level Meter Calibration: ■ checked by: S.R.	
Interior Ambient Noise Level dB(A): < 30.0	Exterior Ambient Noise Level dB(A): 41.9
Microphone Height During Testing (in): 29” above seat cushion.	

Measurement Location	Measured Sound Level dB(A)
Driver’s Seat	71.7
Front Passenger Seats	72.4
Middle Passenger Seats	73.4
Rear Passenger Seats	75.8

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

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

Bus Number: 1403	Date: 6-25-14
Personnel: T.S., S.R. & R.S.	
Temperature (°F): 80	Humidity (%): 74
Wind Speed (mph): < 12 mph	Wind Direction: S
Barometric Pressure (in.Hg): 29.09	

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

Source of Noise	Location
Engine and Accessories	None noted.
Windows and Doors	Sign above R.S. W/C position Squeaking.
Seats and Wheel Chair lifts	None noted.

Comment on any other vibration or noise source which may have occurred
that is not described above: Sign above R.S. W/C position Squeaking.
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 43.0 dB(A), the average test result obtained while accelerating from a constant speed was 73.6 dB(A) on the right side and 73.9 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 43.8 dB(A), the average of the results obtained were 74.1 dB(A) on the right side and 75.3 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 57.8 dB(A) at low idle, 62.3 dB(A) at high idle, and 73.2 dB(A) at wide open throttle. With the accessories and air conditioning off, the readings averaged 3.7 dB(A) lower at low idle, 5.0 dB(A) lower at high idle, and 0.4 dB(A) higher at wide open throttle. The exterior ambient noise level measured during this test was 43.7 dB(A).

EXTERIOR NOISE TEST DATA FORM
Accelerating from Constant Speed

Bus Number: 1403	Date: 6-25-14
Personnel: T.S., S.R. & R.S.	
Temperature (°F): 80	Humidity (%): 70
Wind Speed (mph): < 12 MPH	Wind Direction: SSW
Barometric Pressure (in.Hg): 28.80	
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: S.R.	
Initial Sound Level Meter Calibration: ■ checked by: T.S.	
Exterior Ambient Noise Level dB(A): 43.0	

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	72.6	1	74.1
2	74.0	2	73.0
3	73.2	3	72.6
4	71.1	4	72.2
5	73.0	5	73.6
Average of two highest actual noise levels = 73.6 dB(A)		Average of two highest actual noise levels = 73.9 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

Bus Number: 1403	Date: 6-25-14
Personnel: T.S., S.R. & R.S.	
Temperature (°F): 80	Humidity (%): 70
Wind Speed (mph): < 12 MPH	Wind Direction: SSW
Barometric Pressure (in.Hg): 28.93	
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: S.R.	
Initial Sound Level Meter Calibration: ■ checked by: T.S.	
Exterior Ambient Noise Level dB(A): 43.8	

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	73.6	1	74.4
2	73.1	2	73.6
3	73.0	3	73.9
4	74.2	4	75.3
5	74.0	5	75.2
Average of two highest actual noise levels = 74.1 dB(A)		Average of two highest actual noise levels = 75.3 dB(A)	

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

EXTERIOR NOISE TEST DATA FORM
Stationary

Bus Number: 1403	Date: 6-25-14
Personnel: T.S., S.R. & R.S.	
Temperature (°F): 81	Humidity (%): 71
Wind Speed (mph): < 12 mph	Wind Direction: SSW
Barometric Pressure (in.Hg): 28.96	

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: S.R.

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

Exterior Ambient Noise Level dB(A): 43.7

Accessories and Air Conditioning ON

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	695	58.5	57.0
High Idle	999	64.5	60.0
Wide Open Throttle	2,365	72.1	74.3

Accessories and Air Conditioning OFF

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	705	54.6	53.5
High Idle	1,000	56.4	58.2
Wide Open Throttle	2,403	72.7	74.5

Final Sound Level Meter Calibration Check: ■ checked by: S.R.

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, NOx, 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.

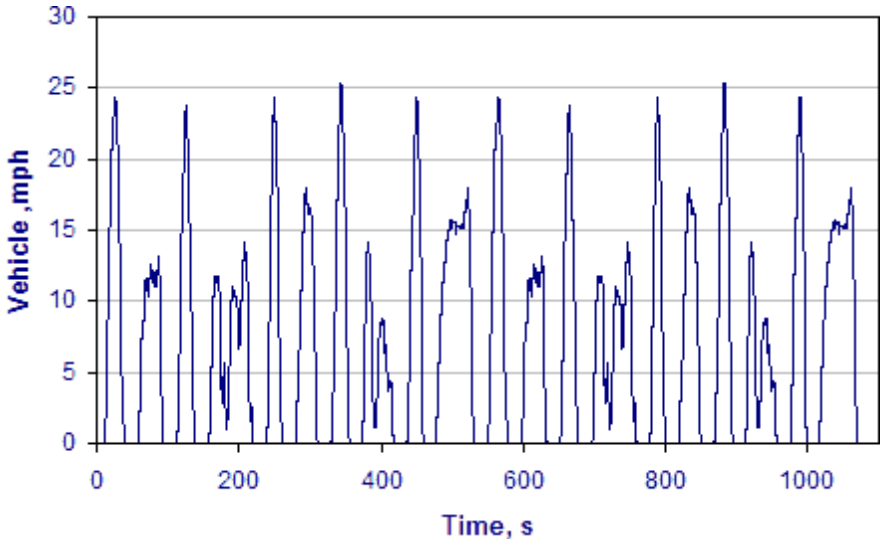


***Figure 1**. Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4mph, average speed 6.8mph)*

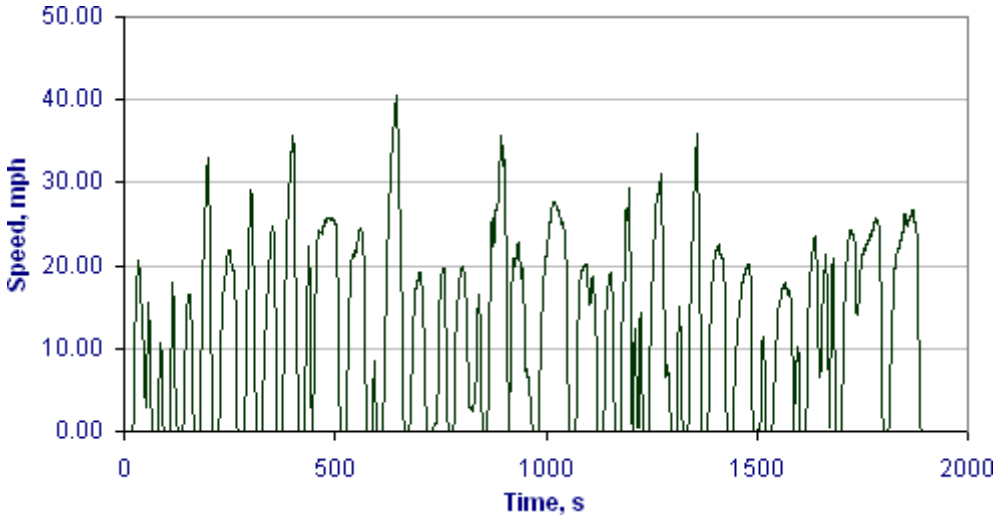


***Figure 2**. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41mph, Average Speed 12mph)*

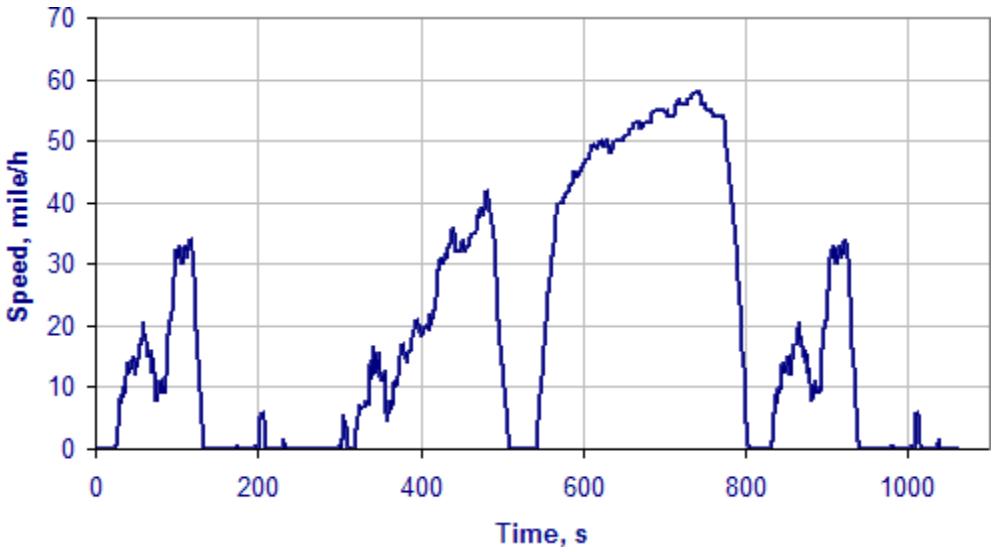


***Figure 3**. HD-UDDS Cycle (duration 1060seconds, Maximum Speed 58mph, Average Speed 18.86mph)*

8-III. TEST ARTICLE

The test article is a New Flyer of America model XN40 transit bus equipped with CNG Cummins ISL-G 8.9 L 280 Hp engine. The bus was tested on June 10, 2014.

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 NOx are sampled by Horiba heated oven analyzers. Gaseous
emissions for CO, CO2 and cold NOx 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

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM

Bus Number: 1403	Date: 6-5-14	SLW (lbs.): 35,390
Personnel: S.R., T.G. & R.S.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	✓	6-2-14	S.R.
Replace fuel filter	✓	5-15-14	E.D.
Check for fuel leaks	✓	6-2-14	S.R.
Specify fuel type (refer to fuel analysis)	CNG		
Remarks: None noted.			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	6-5-14	S.R.
Inspect brakes	✓	6-5-14	S.R.
Relube wheel bearings	✓	6-5-14	S.R.
Check tire inflation pressures (mfg. specs.)	✓	6-5-14	S.R.
Remarks: None noted.			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	6-5-14	S.R.
Check system for coolant leaks	✓	6-5-14	S.R.
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM

Bus Number: 1403	Date: 6-5-14
Personnel: S.R., T.G. & R.S.	

ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	6-5-14	T.G.
Inspect wiring	✓	6-5-14	T.G.
Inspect terminals	✓	6-5-14	T.G.
Check lighting	✓	6-5-14	T.G.
Remarks: None noted.			
DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	5-15-14	E.D.
Replace filter/gasket	✓	5-15-14	E.D.
Check hoses and connections	✓	6-5-14	T.G.
Replace transmission fluid	✓	5-15-14	E.D.
Check for fluid leaks	✓	6-5-14	T.G.
Remarks: None noted.			
LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	5-15-14	E.D.
Replace filters	✓	5-15-14	E.D.
Replace crankcase oil	✓	5-15-14	E.D.
Check for oil leaks	✓	6-5-14	T.G.
Check oil level	✓	6-5-14	T.G.
Lube all chassis grease fittings	✓	6-5-14	T.G.
Lube universal joints	✓	6-5-14	T.G.
Replace differential lube including axles			
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST MAINTENANCE FORM

Bus Number: 1403	Date: 6-5-14
Personnel: S.R., T.G. & R.S.	

EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	✓	6-5-14	T.G.
Remarks: None noted.			

ENGINE	OK	Date	Initials
Replace air filter	✓	5-15-14	E.D.
Inspect air compressor and air system	✓	6-5-14	T.G.
Inspect vacuum system, if applicable	**N/A**	6-5-14	R.R.
Check and adjust all drive belts	✓	6-5-14	T.G.
Check cold start assist, if applicable	✓	6-5-14	T.G.
Remarks: None noted.			

STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors	✓	6-5-14	T.G.
Service fluid level	✓	6-5-14	T.G.
Check power steering operation	✓	6-5-14	T.G.
Remarks: None noted.			

	OK	Date	Initials
Ballast bus to seated load weight	✓	6-5-14	S.R.

TEST DRIVE	OK	Date	Initials
Check brake operation	✓	6-5-14	T.G.
Check transmission operation	✓	6-5-14	T.G.
Remarks: None noted.			

FUEL ECONOMY/EMISSIONS PRE-TEST INSPECTION FORM

Bus Number: 1403	Date: 6-5-14
Personnel: S.R., T.G. & R.S.	

PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	S.R.
Cold tire pressure (psi): Front 120 Middle N/A Rear 118	S.R.
Tire wear: less than 50%	S.R.
Engine oil level	S.R.
Engine coolant level	S.R.
Interior and exterior lights on, evaporator fan on	S.R.
Fuel economy instrumentation installed and working properly.	S.R.
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	S.R.
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 122 Middle N/A Rear 120	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.

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

Test Completed at Half SLW: 35,390 lbs.			
Driving Cycle	**Manhattan**	**Orange County Bus**	**UDDS**
CO_2, gm/mi	2,815	1,820	1,475
CO, gm/mi	23.8	10.7	14.7
THC, gm/mi	9.3	5.9	4.3
NMHC, gm/mi	0	0	0
NO_x, gm/mi	0.6	0.45	0.90
Particulates. gm/mi	N/A	N/A	N/A
Fuel consumption Scf/M	53.4	33.3	27.0