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
Model: XDE60

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

OCTOBER 2014

Report Number: LTI-BT-R1410-P

PENNSTATE

1855

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Performed for the Federal Transit Administration U.S. DOT
1200 New Jersey Avenue, SE
Washington, DC 20590

In accordance with CFR 49, Volume 7, Part 665

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214 Fifth Avenue, SW
Crookston, MN 56716

Model: XDE60

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ACCREDITED
Mechanical Testing Certificate 3172.01

Quality Authorization

Director, Bus Research and Testing Center
Title

10/30/14
Date

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EXECUTIVE SUMMARY

New Flyer submitted a model XDE60, diesel-powered 47 seat (including the driver) 61-foot bus, for a Partial STURAA test in the 12yr/500,000 mile category. The Federal Transit Administration determined that the following tests would be performed; 4. Performance, 6. Fuel Economy, 7.1 Interior Noise Tests, 7.2 Exterior Noise Tests and 8. Emissions. Testing started on September 11, 2014 and was completed on September 26, 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 47 passengers including the driver. Free floor space will accommodate 81 standing passengers resulting in a potential load of 128 persons. At 150 lbs per person, this load results in a measured gross vehicle weight of 61,750 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 41.70 seconds. Top speed acquired on the dynamometer was 65 mph.

A Fuel Economy Test was run on simulated central business district, arterial, and commuter courses. The results were 3.87 mpg, 3.38 mpg, and 5.86 mpg respectively; with an overall average of 4.09 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
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, model XDE60. The bus has a front door, forward of the front axle, a middle door forward of the middle axle and a rear door forward of the rear axle. Power is provided by a diesel-fueled, Cummins model ISL 9 engine coupled to a BAE Systems model Hybrid Drive Traction Motor.

The measured curb weight is 10,240 lbs. for the front axle, 11,800 lbs. for the middle axle and 20,750 lbs. for the rear axle. These combined weights provide a total measured curb weight of 42,790 lbs. There are 47 seats including the driver and room for 81 standing passengers bringing the total passenger capacity to 128. Gross load is 150 lb x 128 = 19,200 lbs. At full capacity, the measured gross vehicle weight is 61,750 lbs.

VEHICLE DATA FORM

Bus Number: 1410	Arrival Date: 09-11-14
Bus Manufacturer: New Flyer of America, Inc.	Vehicle Identification Number (VIN): 5FYH8YU16EB044383
Model Number: XDE60	Date: 09-11-14
Personnel: S.R., E.D. & E.L.	

WEIGHT:

Individual Wheel Reactions:

Weights (lb)	Front Axle		Middle Axle		Rear Axle	
	Right	Left	Right	Left	Right	Left
CW	5,060	5,180	6,600	5,200	9,280	11,470
SLW	5,740	5,850	7,880	6,410	10,570	13,380
GVW	6,510	6,630	11,110	10,020	11,500	15,980

Total Weight Details:

Weight (lb)	CW	SLW	GVW	GAWR
Front Axle	10,240	11,590	13,140	14,780
Middle Axle	11,800	14,290	21,130	24,250
Rear Axle	20,750	23,950	27,480	27,760
Total	42,790	49,830	61,750	GVWR: 66,790

Dimensions:

Length (ft/in)	61/6.75
Width (in)	102.0
Height (in)	130.5
Front Overhang (in)	96.0
Rear Overhang (in)	119.75
Wheel Base (in)	Front: 229.5 Rear: 293.5
Wheel Track (in)	Front: 86.4
	Rear: 74.7 Middle: 76.0

Bus Number: 1410	Date: 09-11-14

CLEARANCES:

Lowest Point Outside Front Axle	Location: Wheelchair Ramp Clearance(in): 9.6
Lowest Point Outside Rear Axle	Location: Wire Guard Clearance(in): 10.9
Lowest Point between Axles	Location: Front –Frame Clearance(in): 10.1 Rear – Jacking Point Clearance(in): 9.3
Ground Clearance at the center (in)	11.7
Front Approach Angle (deg)	7.1
Rear Approach Angle (deg)	9.4
Ramp Clearance Angle (deg)	Front: 5.0 Rear: 3.6
Aisle Width (in)	Front: 22.3 Rear: 22.8
Inside Standing Height at Center Aisle (in)	Front: 94.8 Rear: 79.6

BODY DETAILS:

Body Structural Type	Semi-Monocoque		
Frame Material	Steel		
Body Material	Fiberglass		
Floor Material	Plywood		
Roof Material	Fiberglass		
Windows Type	☑ Fixed	☑ Movable (Top)	
Window Mfg./Model No.	Arow / Tempered AS3 DOT 411		
Number of Doors	1 Front	1 Middle	1 Rear
Mfr. / Model No.	Vapor Bus International Front: 14G0062 Middle:14F0001 Rear:14E0031		
Dimension of Each Door (in)	Front: 34.5 x 77.5	Middle 39.3 x 77.6	Rear: 39.8 x 77.6
Passenger Seat Type	☑ Cantilever	☑ Pedestal	☐ Other (explain)
Mfr. / Model No.	N/A		
Driver Seat Type	☑ Air	☐ Spring	☐ Other (explain)
Mfr. / Model No.	USSC, LLC / SN #250165		
Number of Seats (including Driver)	47 (7 fold away for 2 wheelchair positions)		

Bus Number: 1410	Date: 09-11-14

BODY DETAILS (Cont.)

Free Floor Space (ft^2)	125.1			
Height of Each Step at Normal Position (in)	Front 1. 14.0	2. ?	3. ?	4. ?
	Middle 1. 14.3	2. ?	3. ?	4. ?
	Rear 1. 14.4	2. ?	3. ?	4. ?
Step Elevation Change - Kneeling (in)	Front: 5.4	Middle: 2.0	Rear: 0.6	

ENGINE

Type	☑ C.I.	☐ Alternate Fuel	
	☐ S.I.	☐ Other (explain)	
Mfr. / Model No.	Cummins / ISL9 330 HP		
Location	☐ Front	☑ Rear	☐ Other (explain)
Fuel Type	☐ Gasoline	☐ CNG	☐ Methanol
	☑ Diesel	☐ LNG	☐ Other (explain)
Fuel Tank Capacity (gallons)	143		
Fuel Induction Type	☑ Injected	☐ Carburetion	
Fuel Injector Mfr. / Model No.	Cummins / ISL9 330 HP		
Carburetor Mfr. / Model No.	N/A		
Fuel Pump Mfr. / Model No.	Cummins / ISL9 330 HP		
Alternator (Generator) Mfr. / Model No.	Not equipped		
Maximum Rated Output (Volts / Amps)	N/A		
Air Compressor Mfr. / Model No.	Wabco / 5286681		
Maximum Capacity (ft^3 / min)	30.4		
Starter Type	☑ Electrical	☐ Pneumatic	☑ Other (explain)
Starter Mfr. / Model No.	BAE Systems Hybri Drive Traction Motor		

VEHICLE DATA FORM

Bus Number: 1410	Date: 09-11-14

TRANSMISSION

Transmission Type	☐ Manual	☑ Automatic	
Mfr. / Model No.	BAE Systems Hybri Drive Traction Motor / 13HDS300TMGBX180-1		
Control Type	☐ Mechanical	☑ Electrical	☐ Other
Torque Converter Mfr. / Model No.	N/A		
Integral Retarder Mfr. / Model No.	N/A		

SUSPENSION

Number of Axles	3		
Front Axle Type	☐ Independent	☑ Beam Axle	
Mfr. / Model No.	MAN / VOK-07-F S/N: AGGV0K07FB4140816		
Axle Ratio (if driven)	N/A		
Suspension Type	☑ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Koni / 90 2517 SP1		
Middle Axle Type	☐ Independent	☑ Beam Axle	
Mfr. / Model No.	ZF / SN 472465		
Axle Ratio (if driven)	N/A		
Suspension Type	☑ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	4		
Mfr. / Model No.	Koni / 90 2518 SP1		
Rear Axle Type	☐ Independent	☑ Beam Axle	
Mfr. / Model No.	MAN / 140295 / SN:AGGHY1350F7140295		
Axle Ratio (if driven)	4.56		
Suspension Type	☑ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	4		
Mfr. / Model No.	Koni / 90 2518 SP1		

Bus Number: 1410	Date: 09-11-14

WHEELS & TIRES

Front	Wheel Mfr./ Model No.	Alcoa 22.5 x 8.25
	Tire Mfr./ Model No.	Goodyear Metro Miler 305/70R 22.5
Middle	Wheel Mfr./ Model No.	Alcoa 22.5 x 8.25
	Tire Mfr./ Model No.	Goodyear Metro Miler 305/70R 22.5
Rear	Wheel Mfr./ Model No.	Alcoa 22.5 x 8.25
	Tire Mfr./ Model No.	Goodyear Metro Miler 305/70R 22.5

BRAKES

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

HVAC

Heating System Type	☐ Air	☑ Water	☐ Other
Capacity (Btu/hr)	Front rooftop – 105,000 Rear rooftop – 105,000 Defroster – 84,000		
Mfr. / Model No.	Thermoking / RLFE1HPMV-M1/RLF2E-M7		
Air Conditioner	☑ Yes	☐ No	
Location	Rear and Roof		
Capacity (Btu/hr)	Front rooftop – 68,000 Rear rooftop – 64,000		
A/C Compressor Mfr. / Model No.	Copeland Scroll / ZR81KCE		

Bus Number: 1410	Date: 09-11-14

STEERING

Steering Gear Box Type	Hydraulic Gear
Mfr. / Model No.	RH Shepphard Co., Inc. / M110PRN31
Steering Wheel Diameter (in)	16.1
Number of turns (lock to lock)	4.0

OTHERS

Wheel Chair Ramps	Location: Front	Type: Foldout Ramp
Wheel Chair Lifts	Location: N/A	Type: N/A
Mfr. / Model No.	New Flyer / Ramp 1:7 slope	
Emergency Exit	Location: Doors Windows Roof Hatch	Number: 3 13 2

CAPACITIES

Fuel Tank Capacity (gallons)	143
Engine Crankcase Capacity (gallons)	5.75
Hybrid Drive System Capacity (gallons)	3.0
Differential Capacity (gallons)	3.83
Cooling System Capacity (quarts)	30.0
Power Steering Fluid Capacity (gals)	11.0

OTHERS

Articulated turn table Mfr. / Model No.	ATG / AUTOTECHNIK GMBH 6237

VEHICLE DATA FORM

Bus Number: 1410	Date: 09-11-14

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

Part Number	Description	Qty.
N/A	N/A	

COMPONENT/SUBSYSTEM INSPECTION FORM

Bus Number: 1410	Date: 09-17-14

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.	

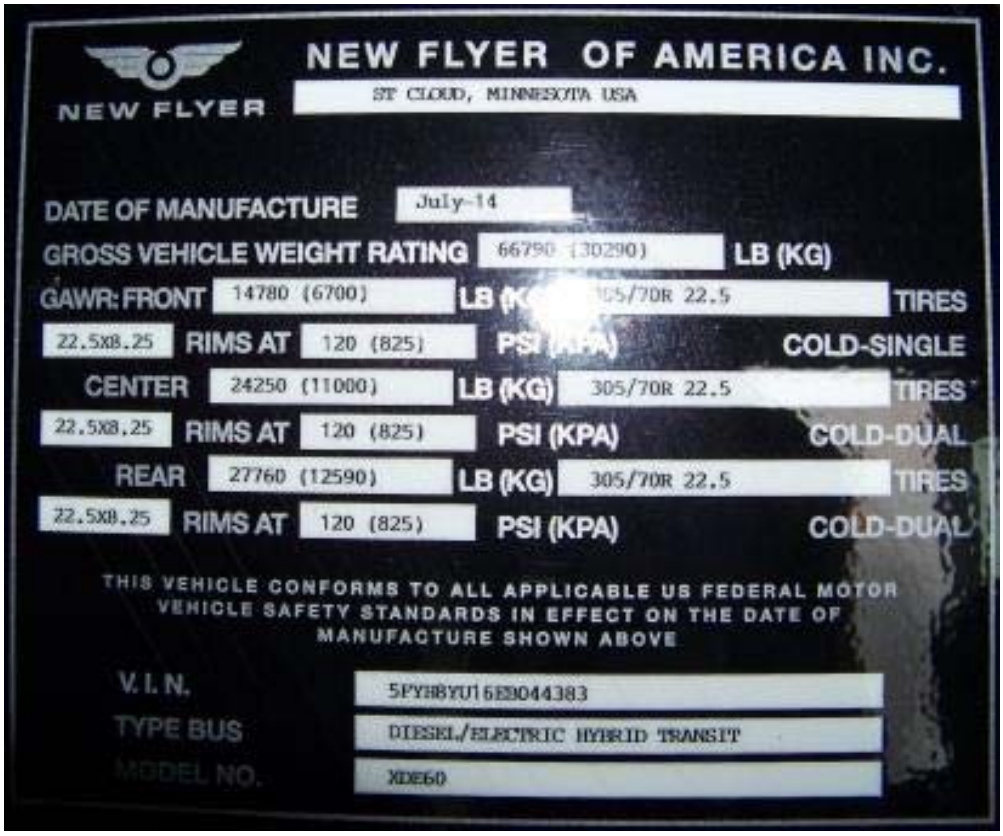
CHECK - IN

NEW FLYER
MODEL XDE60

CHECK - IN CONT.

NEW FLYER MODEL XDE60
EQUIPPED WITH A NEW FLYER FOLDOUT HANDICAP RAMP

CHECK – IN CONT.



VIN TAG

OPERATOR'S AREA

4.0 PERFORMANCE

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

4.1-I. TEST OBJECTIVE

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

4.1-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.

4.1-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 41.70 seconds. Top speed obtained on the dynamometer was 65 mph.

PERFORMANCE DATA FORM

Bus Number: 1410	Date: 09-22-14
Personnel: T.S., S.R. & M.H.	

Temperature (°F): 57	Humidity (%): 72
Wind Direction: N	Wind Speed (mph): 8.9
Barometric Pressure (in.Hg): 30.03	

		INITIALS:
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	4.15	4.34	4.20
20 mph	8.22	8.41	8.20
30 mph	14.20	14.15	14.01
40 mph	25.94	24.08	23.51
Top Test Speed(mph) 50	46.71	44.25	43.39

Clockwise Recorded Interval Times

Speed	Run 1	Run 2	Run 3
10 mph	4.09	4.53	3.96
20 mph	7.94	7.96	8.00
30 mph	13.65	13.89	13.78
40 mph	23.21	22.70	22.93
Top Test Speed(mph) 50	39.27	38.39	38.18

PERFORMANCE SUMMARY SHEET

BUS MANUFACTURER :**New Flyer** BUS NUMBER :**1410**
BUS MODEL :**XDE60** TEST DATE :09/22/14

TEST CONDITIONS :

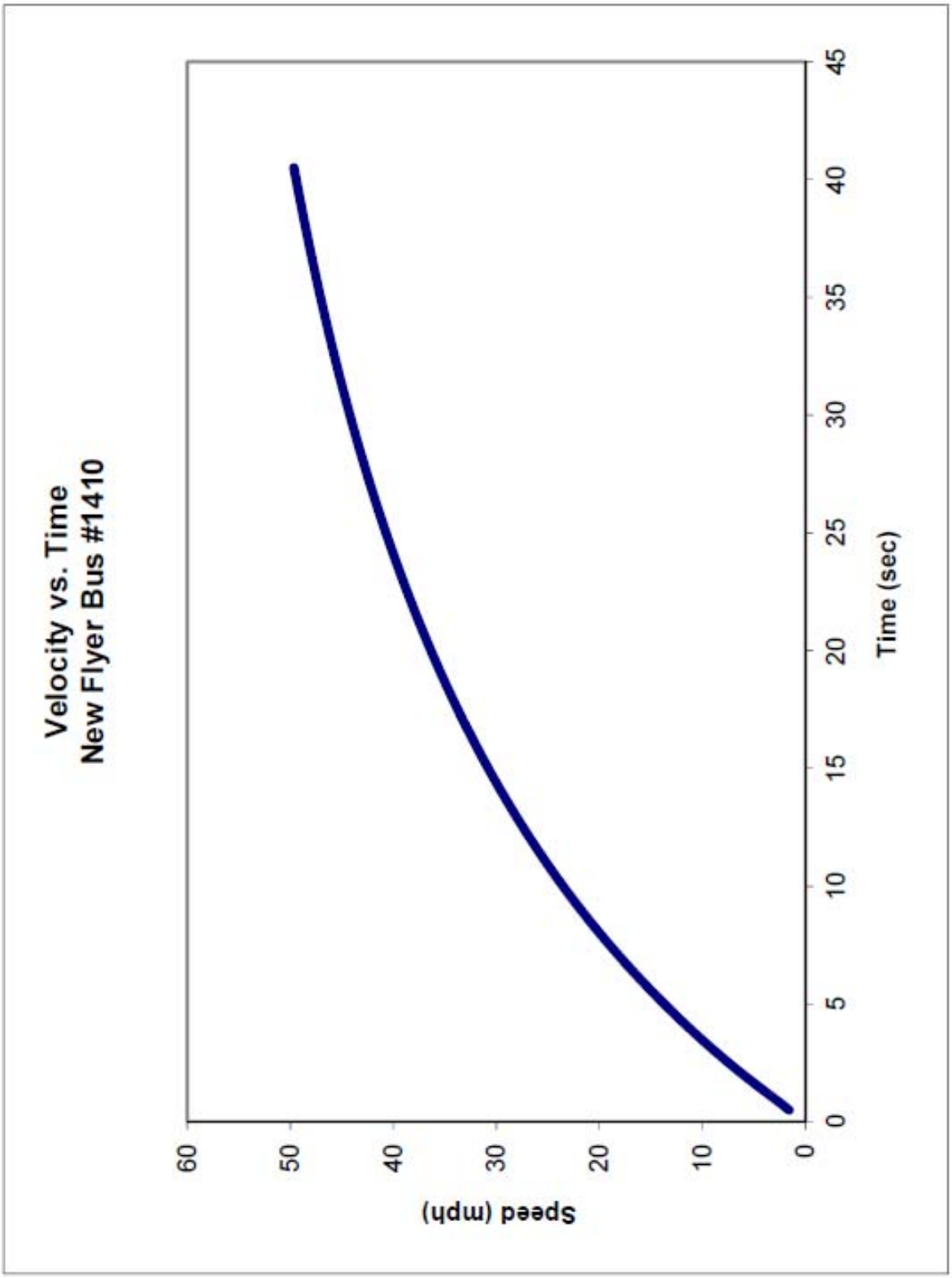
TEMPERATURE (DEG F) : 57.0
WIND DIRECTION : N
WIND SPEED (MPH) : 8.9
HUMIDITY (%) : 72
BAROMETRIC PRESSURE (IN. HG) : 30.0

VEHICLE SPEED (MPH)	AVERAGE TIME (SEC)		
	CCW DIRECTION	CW DIRECTION	TOTAL
10.0	4.23	4.19	4.21
20.0	8.28	7.97	8.12
30.0	14.12	13.77	13.95
40.0	24.51	22.95	23.73
50.0	44.78	38.61	41.70

TEST SUMMARY :

VEHICLE SPEED (MPH)	TIME (SEC)	ACCELERATION (FT/SEC^2)	MAX. GRADE (%)
1.0	.31	4.7	14.6
5.0	1.63	4.2	13.3
10.0	3.47	3.7	11.7
15.0	5.57	3.2	10.1
20.0	8.02	2.8	8.6
25.0	10.91	2.3	7.2
30.0	14.39	1.9	5.9
35.0	18.67	1.5	4.8
40.0	24.11	1.2	3.7
45.0	31.30	.9	2.7
50.0	41.35	.6	1.9

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 #1410
Speed (mph)
0
10
20
30
40
50
60
Time (sec)
0
5
10
15
20
25
30
35
40
45

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 flowmeter 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 flowmeter 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 60EF (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 60EF. 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

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

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°F). 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 diesel fuel with a heating value of 19,568.0 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 – 3.87 mpg, ART – 3.38 mpg, and COM – 5.86 mpg. Average fuel consumption at idle was 0.61 gph.

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1410	Date: 09-24-14	SLW (lbs): 49,830
Personnel: T.S. & E.D.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	✓	09/24/14	T.S.
Replace fuel filter	✓	09/24/14	T.S.
Check for fuel leaks	✓	09/24/14	T.S.
Specify fuel type (refer to fuel analysis)	Diesel		
Remarks: None noted			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	09/24/14	T.S.
Inspect brakes	✓	09/24/14	T.S.
Relube wheel bearings	✓	09/24/14	T.S.
Check tire inflation pressures (mfg. specs.)	✓	09/24/14	T.S.
Remarks: None noted			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	09/24/14	T.S.
Check system for coolant leaks	✓	09/24/14	T.S.
Remarks: None noted			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1410	Date: 09-24-14
Personnel: T.S. & E.D.	

ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	09/24/14	E.D.
Inspect wiring	✓	09/24/14	E.D.
Inspect terminals	✓	09/24/14	E.D.
Check lighting	✓	09/24/14	E.D.
Remarks: None noted			

DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	09/24/14	E.D.
Replace filter/gasket	✓	09/24/14	E.D.
Check hoses and connections	✓	09/24/14	E.D.
Replace transmission fluid	✓	09/24/14	E.D.
Check for fluid leaks	✓	09/24/14	E.D.
Remarks: Done by bus manufacturer			

LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	09/24/14	T.S.
Replace filters	✓	09/24/14	T.S.
Replace crankcase oil	✓	09/24/14	T.S.
Check for oil leaks	✓	09/24/14	T.S.
Check oil level	✓	09/24/14	E.D.
Lube all chassis grease fittings	✓	09/24/14	E.D.
Lube universal joints	✓	09/24/14	E.D.
Replace differential lube including axles	✓	09/24/14	E.D.
Remarks: Done by bus manufacturer			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1410	Date: 09-24-14
Personnel: T.S. & E.D.	

EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	✓	09/24/14	E.D.
Remarks: None noted			

ENGINE	OK	Date	Initials
Replace air filter (New from Manufacturer)	✓	09/24/14	E.D.
Inspect air compressor and air system	✓	09/24/14	E.D.
Inspect vacuum system, if applicable	✓	09/24/14	E.D.
Check and adjust all drive belts	✓	09/24/14	E.D.
Check cold start assist, if applicable	✓	09/24/14	E.D.
Remarks: None noted			

STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors	✓	09/24/14	T.S.
Service fluid level	✓	09/24/14	T.S.
Check power steering operation	✓	09/24/14	T.S.
Remarks: None noted			

	OK	Date	Initials
Ballast bus to seated load weight	✓	09/24/14	T.S.

TEST DRIVE	OK	Date	Initials
Check brake operation	✓	09/24/14	T.S.
Check transmission operation	✓	09/24/14	T.S.
Remarks: None noted			

FUEL ECONOMY PRE-TEST INSPECTION FORM

Bus Number: 1410	Date: 09-25-14
Personnel: T.S., E.L. & C.S.	

PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	T.S.
Cold tire pressure (psi): Front 120 Middle 120 Rear 120	E.L.
Tire wear: less than 50%	T.S.
Engine oil level	C.S.
Engine coolant level	C.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	T.S.
Speed measuring system installed on bus. Speed indicator installed in front of bus and accessible to TECH and Driver.	T.S.
Bus is loaded to SLW	T.S.
WARM-UP	**If OK, Initial**
Bus driven for at least one hour warm-up	C.S.
No extensive or black smoke from exhaust	C.S.
POST WARM-UP	**If OK, Initial**
Warm tire pressure (psi): Front 125 Middle 125 Rear 125	T.S.
Environmental conditions Average wind speed <12 mph and maximum gusts <15 mph Ambient temperature between 30°F(-1C°) and 90°F(32°C) Track surface is dry Track is free of extraneous material and clear of interfering traffic	T.S.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Bus Number: 1410	Manufacturer: New Flyer	Date: 09-25-14
Run Number: 1	Personnel: T.S., E.L. & C.S.	
Test Direction: ☐CW or ☑CCW	Temperature (°F): 60	Humidity (%): 88
SLW (lbs): 49,830	Wind Speed (mph) & Direction:2.7/NNE	Barometric Pressure (in.Hg): 30.42

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	9:10	9:10	18.0	0	.481	.481
ART #1	0	4:19	4:19	18.7	0	.512	.512
CBD #2	0	9:05	9:05	19.3	0	.428	.428
ART #2	0	4:14	4:14	19.3	0	.517	.517
CBD #3	0	9:08	9:08	19.1	0	.475	.475
COMMUTER	0	6:07	6:07	19.9	0	.600	.600
						Total Fuel =	3.01 gals

20 minute idle : Total Fuel Used = .183 gals
Heating Value = 19,568 BTU/LB
Comments: Bus has automatic shutdown at idle.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Bus Number: 1410	Manufacturer: New Flyer	Date: 09-25-14
Run Number: 2	Personnel: T.S., E.L. & C.S.	
Test Direction: ☑CW or ☐CCW	Temperature (°F): 62	Humidity (%): 77
SLW (lbs): 49,830	Wind Speed (mph) & Direction: 2.5/ENE	Barometric Pressure (in.Hg): 30.41

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	9:15	9:15	19.6	0	.473	.473
ART #1	0	4:20	4:20	20.6	0	.521	.521
CBD #2	0	9:11	9:11	21.3	0	.420	.420
ART #2	0	4:20	4:20	21.3	0	.483	.483
CBD #3	0	9:12	9:12	22.1	0	.438	.438
COMMUTER	0	6:05	6:05	21.8	0	.593	.593
							Total Fuel = 2.928 gals

20 minute idle : Total Fuel Used = N/A gals
Heating Value = 19,568 BTU/LB
Remarks/comments/recommended changes: None noted.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Bus Number: 1410	Manufacturer: New Flyer	Date: 09-25-14
Run Number: 3	Personnel: T.S., E.L. & C.S.	
Test Direction: ☐CW or ☑CCW	Temperature (°F): 63.5	Humidity (%): 72
SLW (lbs): 49,830	Wind Speed (mph) & Direction: 4.5/E	Barometric Pressure (in.Hg): 30.38

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	9:16	9:16	22.8	0	.452	.452
ART #1	0	4:14	4:14	23.7	0	.514	.514
CBD #2	0	9:04	9:04	25.1	0	.445	.445
ART #2	0	4:19	4:19	24.5	0	.524	.524
CBD #3	0	9:08	9:08	25.6	0	.469	.469
COMMUTER	0	6:03	6:03	25.3	0	.604	.604
							Total Fuel = 3.008 gals

20 minute idle : Total Fuel Used = N/A gals
Heating Value = 19,568 BTU/LB
Remarks/comments/recommended changes: None noted.

FUEL ECONOMY DATA FORM (Liquid Fuels)

Bus Number: 1410	Manufacturer: New Flyer	Date: 09-25-14
Run Number: 4	Personnel: T.S., E.L. & C.S.	
Test Direction: ☑CW or ☐CCW	Temperature (°F): 69	Humidity (%): 73
SLW (lbs): 49,830	Wind Speed (mph) & Direction: 2.5/E	Barometric Pressure (in.Hg): 30.35

Cycle Type	Time (min:sec)		Cycle Time (min:sec)	Fuel Temperature (°C)	Flow Meter Reading (gals)		Fuel Used (gals)
	Start	Finish		Start	Start	Finish	
CBD #1	0	9:16	9:16	25.0	0	.453	.453
ART #1	0	4:16	4:16	25.7	0	.517	.517
CBD #2	0	8:55	8:55	27.1	0	.408	.408
ART #2	0	4:17	4:17	26.4	0	.521	.521
CBD #3	0	8:54	8:54	27.8	0	.443	.443
COMMUTER	0	6:09	6:09	27.3	0	.572	.572
							Total Fuel = 2.914 gals

20 minute idle : Total Fuel Used = .184 gals
Heating Value = 19,568 BTU/LB
Remarks/comments/recommended changes: None noted.

FUEL ECONOMY SUMMARY SHEET

BUS MANUFACTURER : **New Flyer** BUS NUMBER: **1410**
BUS MODEL : **XDE60** TEST DATE : 09/25/14

FUEL TYPE : DIESEL
SP. GRAVITY : .8505
HEATING VALUE : 19568.00 BTU/Lb
FUEL TEMPERATURE : 72.00 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)
Run #:1 CCW				
CBD	1.381	5.73	4.149	3.77
ART	1.029	3.82	3.712	3.37
COM	.600	3.82	6.367	5.78
TOTAL	3.010	13.37	4.442	4.03
Run #:2 CW				
CBD	1.331	5.73	4.305	3.91
ART	1.004	3.82	3.805	3.45
COM	.593	3.82	6.442	5.85
TOTAL	2.928	13.37	4.566	4.14
Run #:3 CCW				
CBD	1.366	5.73	4.195	3.81
ART	1.038	3.82	3.680	3.34
COM	.604	3.82	6.325	5.74
TOTAL	3.008	13.37	4.445	4.03
Run #:4 CW				
CBD	1.304	5.73	4.394	3.99
ART	1.038	3.82	3.680	3.34
COM	.572	3.82	6.678	6.06
TOTAL	2.914	13.37	4.588	4.16

IDLE CONSUMPTION (MEASURED)

First 20 Minutes Data : .18GAL Last 20 Minutes Data: .18GAL
Average Idle Consumption: .55GAL/Hr.

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

Run 1 : -1.5 Run 2 : 1.2 Run 3 : -1.5 Run 4 : 1.7

SUMMARY (CORRECTED VALUES)

Average Idle Consumption : .61 G/Hr.
Average CBD Phase Consumption : 3.87 MPG
Average Arterial Phase Consumption: 3.38 MPG
Average Commuter Phase Consumption: 5.86 MPG
Overall Average Fuel Consumption : 4.09 MPG
Overall Average Fuel Consumption : 29.50 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 55.0 dB(A); ranging from 50.2 dB(A) at the driver's seat to 63.0 dB(A) in line with the middle speaker. 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 69.5 dB(A) at the front passenger seats to 74.6 dB(A) at the rear passenger seats. The overall average was 72.4 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

Bus Number: 1410	Date: 9-10-14
Personnel: S.R., E.D. & E.L.	
Temperature (°F): 69	Humidity (%): 90
Wind Speed (mph): < 12 mph	Wind Direction: S
Barometric Pressure (in.Hg): 30.13	
Initial Sound Level Meter Calibration: ■ checked by: S.R.	
Interior Ambient Noise Level dB(A): < 30.0	Exterior Ambient Noise Level dB(A): 45.8
Microphone Height During Testing (in): 29” above seat cushion.	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	50.2
Front Passenger Seats	53.1
In Line with Front Speaker	54.2
In Line with Middle Speaker	63.0
In Line with Rear Speaker	55.7
Rear Passenger Seats	54.0

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

Comments: All readings taken in the center aisle.

Comments: Middle speaker reading was obtained at the articulating joint.

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

Bus Number: 1410	Date: 9-22-14
Personnel: T.S., S.R. & M.H.	
Temperature (°F): 57	Humidity (%): 76
Wind Speed (mph): < 12 mph	Wind Direction: NW
Barometric Pressure (in.Hg): 30.05	
Initial Sound Level Meter Calibration: ■ checked by: 93.6	
Interior Ambient Noise Level dB(A): < 30.0	Exterior Ambient Noise Level dB(A): 44.5
Microphone Height During Testing (in): 48” above floor.	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	72.5
Front Passenger Seats	69.5
Middle Passenger Seats	73.1
Rear Passenger Seats	74.6

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

Comments: All readings taken in the center aisle.
Comments: None noted.

INTERIOR NOISE TEST DATA FORM
Test Condition 3: Audible Vibration Test

Bus Number: 1410	Date: 9-22-14
Personnel: T.S., S.R. & M.H.	
Temperature (°F): 56	Humidity (%): 76
Wind Speed (mph): <12 mph	Wind Direction: NW
Barometric Pressure (in.Hg): 30.05	

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	None noted.
Seats and Wheel Chair lifts	None noted.

Comment on any other vibration or noise source which may have occurred
that is not described above: None noted.
Comments: None noted.

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 up shift.
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 46.0 dB(A), the average test result obtained while accelerating from a constant speed was 74.5 dB(A) on the right side and 74.9 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 49.8 dB(A), the average of the results obtained were 72.9 dB(A) on the right side and 72.1 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 61.5 dB(A) at low idle, 62.7 dB(A) at high idle, and 71.4 dB(A) at wide open throttle. With the accessories and air conditioning off, the readings averaged 1.6 dB(A) lower at low idle, 0.4 dB(A) lower at high idle, and 0.2 dB(A) lower at wide open throttle. The exterior ambient noise level measured during this test was 46.0 dB(A).

EXTERIOR NOISE TEST DATA FORM
Accelerating from Constant Speed

Bus Number: 1410	Date: 9-22-14
Personnel: T.S., S.R. & M.H.	
Temperature (°F): 56	Humidity (%): 71
Wind Speed (mph): < 12 mph	Wind Direction: WNW
Barometric Pressure (in.Hg): 30.07	
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): 46.0	

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	74.9	1	74.7
2	73.6	2	74.7
3	73.5	3	75.0
4	73.2	4	74.6
5	74.0	5	74.4
Average of two highest actual noise levels = 74.5 dB(A)		Average of two highest actual noise levels = 74.9 dB(A)	

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

Comments: None noted.

EXTERIOR NOISE TEST DATA FORM
Accelerating from Standstill

Bus Number: 1410	Date: 9-22-14
Personnel: T.S., S.R. & M.H.	
Temperature (°F): 56	Humidity (%): 70
Wind Speed (mph): <12 mph	Wind Direction: WNW
Barometric Pressure (in.Hg): 30.07	
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): 49.8	

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	73.2	1	71.9
2	71.4	2	69.3
3	72.5	3	69.4
4	72.2	4	72.3
5	71.1	5	69.2
Average of two highest actual noise levels = 72.9 dB(A)		Average of two highest actual noise levels = 72.1 dB(A)	

Final Sound Level Meter Calibration Check: ■ checked by: T.S.
Comments: None noted.

EXTERIOR NOISE TEST DATA FORM
Stationary

Bus Number: 1410	Date: 9-22-14
Personnel: T.S., S.R. & M.H.	
Temperature (°F): 56	Humidity (%): 66
Wind Speed (mph): < 12 mph	Wind Direction: W
Barometric Pressure (in.Hg): 30.09	

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): 46.0

Accessories and Air Conditioning ON

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	700	61.2	61.8
High Idle	1,100	62.9	62.5
Wide Open Throttle	2,175	71.3	71.5

Accessories and Air Conditioning OFF

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	700	59.5	60.3
High Idle	1,100	62.5	63.6
Wide Open Throttle	2,150	71.3	71.9

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

Comments: None noted.

7.2 EXTERIOR NOISE TESTS

TEST BUS UNDERGOING
EXTERIOR NOISE TEST

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.

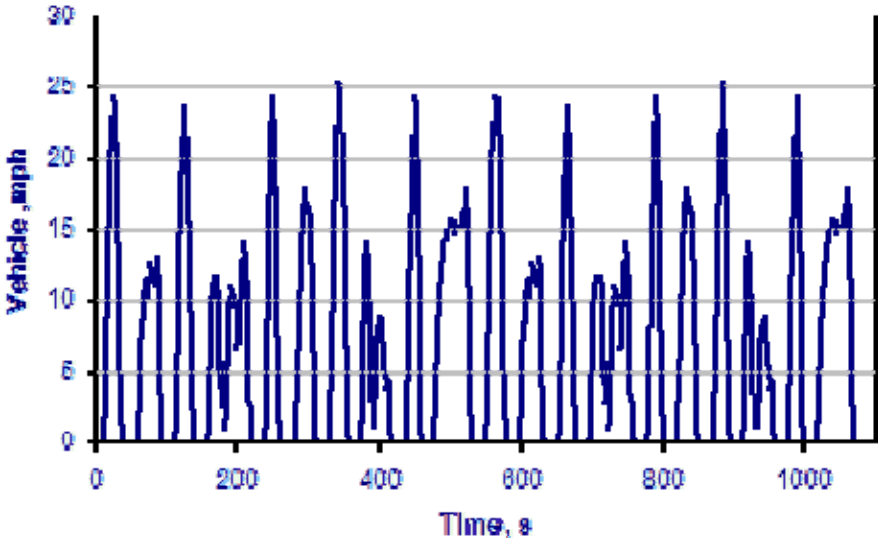


***Figure 1**. Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4mph, average speed 6.8mph)*

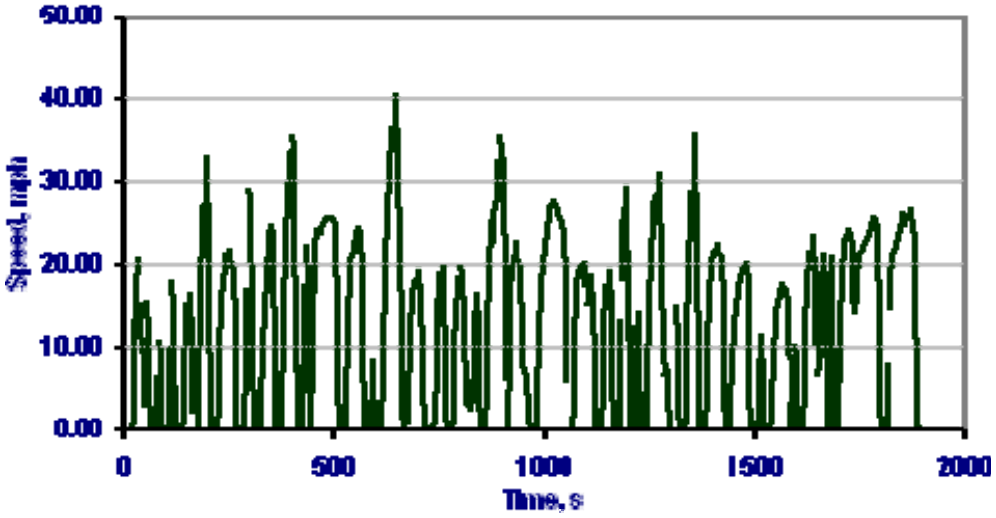


***Figure 2**. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41mph, Average Speed 12mph)*

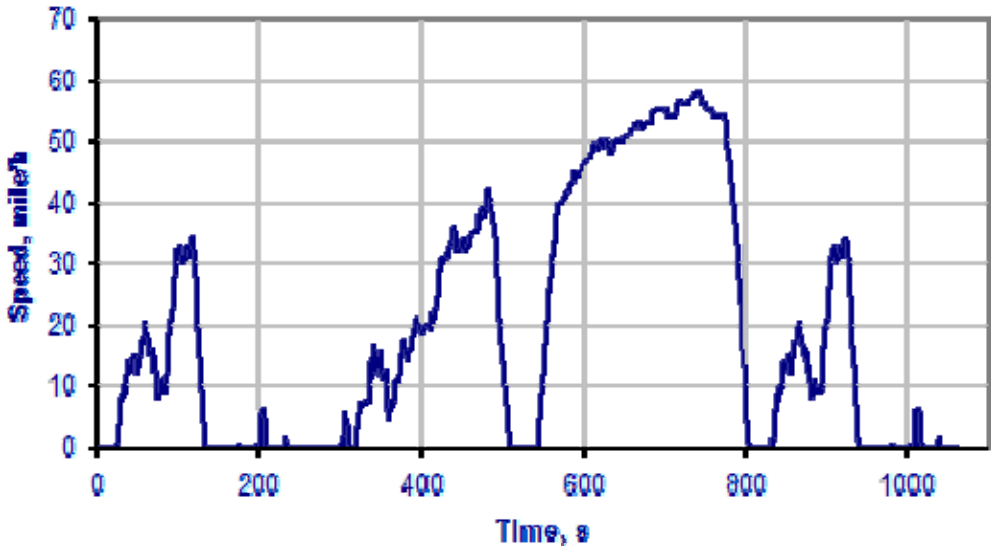


***Figure 3**. HD-UDDS Cycle (duration 1060seconds, Maximum Speed 58mph, Average Speed 18.86mph)*

8-III. TEST ARTICLE

The test article is a New Flyer model XDE60 transit bus equipped with diesel fueled Cummins model ISL 9 330 engine. The bus was tested on October 2, 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

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: 46,290			
Driving Cycle	**Manhattan**	**Orange County Bus**	**UDDS**
CO_2, gm/mi	2,400	2,092	1,871
CO, gm/mi	0.17	0.17	0.17
THC, gm/mi	0.06	0.06	0.04
NMHC, gm/mi	0.05	0.06	0.04
NO_x, gm/mi	0.85	1.48	1.41
Particulates. gm/mi	0.004	0.002	0.003
Fuel consumption mpg	3.84	4.41	4.93