

# **FEDERAL TRANSIT BUS TEST**

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

**Manufacturer: New Flyer of America  
Model: XE40**

**Partial test  
12 Year / 500,000 Miles**

**September 2021**

**Report Number: LTI-BT-R1915-P**

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

In accordance with 49 CFR Part, 665

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Manufacturer's address: 214 5<sup>th</sup> Avenue SW  
Crookston, MN 56716

Model: XE40

Partial Test  
12 Year / 500,000 Miles

Report Number: LTI-BT-R1915-P



*David Klinikowski*

Quality Authorization

Director, Bus Research  
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Title

September 22, 2021

Date

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## EXECUTIVE SUMMARY

### TEST HIGHLIGHTS

The information in this report pertains only to this specific bus, as received from the manufacturer for testing.

The Check-In section of the report provides a description of the bus and specifies its major components. The following table gives the salient specifications.

<b>Manufacturer</b>	New Flyer of America, Inc.
<b>Model</b>	XE40
<b>Chassis Make/Model</b>	New Flyer / XE40
<b>Chassis Modified</b>	No
<b>Length</b>	40 feet, 11 ½ inches
<b>Fuel</b>	Battery-Electric
<b>Service Life</b>	12 year / 500,000 miles - Partial
<b>Baseline Report</b>	LTI-BT-R1405
<b>Number of Seats (including driver)</b>	41 or 35 and 2 wheelchairs
<b>Manufacturer-Designated Standing Passenger Capacity</b>	28
<b>Gross Vehicle Weight used for testing</b>	44,400 lb.
<b>Gross Vehicle Weight Rating</b>	44,533 lb.
<b>Mileage at Delivery</b>	13,962
<b>Test Start Date</b>	December 3, 2019
<b>Test Completion Date</b>	July 20, 2021*
<b>Report Issuance Date</b>	September 22, 2021

\*Due to the COVID-19 pandemic, all bus testing activities were suspended during the period of March 26, 2020, through July 16, 2020.

The measured curb weight was 11,720 lb. for the front axle and 22,320 lb. for the rear axle. These combined weights provided a total measured curb weight of 34,040 lb. There are 41 seats including the driver (or 35 seats and two wheelchairs) and free floor space for 41 standing passengers bringing the potential total passenger capacity to 82. However, a placard shows the maximum number of standing passengers as 28. Therefore, the gross load represents 41 seated passengers and 28 standees only, for a total of 69 passengers, including the driver. Gross load is calculated as 150 lb. x 69 = 10,350lb. At full declared capacity, the measured gross vehicle weight was 44,400 lb. The maximum seated load weight was obtained using the wheelchair positions. Seated load weight is calculated as (150 lb. x 35) + (600 lb. x 2) = 6,450 lb. There is a potential to overload this bus with the additional available floor space for standing passengers or when utilizing both wheelchair positions with maximum allowable standees.

The FTA determined that this bus was required to run additional miles at the end of testing to demonstrate that repairs made adequately corrected two separate failures; one related to the cracks in the frame and the other related to the vehicle going into uncommanded reverse. The additional test miles were successfully completed. Information on these repairs and additional miles is found in Section 5.7.

A Siemens charger was provided by the manufacturer when the bus was submitted for testing. On several occasions throughout the test, this bus had charging issues. These included the charger not recognizing the bus once connected, the bus was unable to charge, and occasionally the bus did not charge to 100% state of charge. The manufacturer's representative made multiple attempts to correct the issue, including installing software updates to the charger. Since the charger used for this bus is not proprietary to the bus, no unscheduled maintenance hours were counted for these repairs and details of the repairs to the charger are not reported. However, the details of these issues can be found in Section 5.7.

## **ABBREVIATIONS AND ACRONYMS**

ABS	- anti-skid braking system
ABTC	- Altoona Bus Test Center
A/C	- air conditioner, or air conditioning
AC	- alternating current
ADA	- American Disability Act
CDCTS	- chassis dynamometer test control system
CVS	- constant volume sampling
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
DC	- direct current
DIR	- test director
DR	- bus driver
EPA	- Environmental Protection Agency
GAWR	- gross axle weight rating
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
HD-UDDS	- Heavy Duty-Urban Dynamometer Driving Schedule
LTI	- Larson Transportation Institute
mpg	- miles per gallon
mph	- miles per hour
PM	- Preventive maintenance
PSTT	- Penn State Test Track
rpm	- revolutions per minute
SAE	- Society of Automotive Engineers
SCF	- Standard cubic foot
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)
TD	- test driver
TECH	- test technician
TM	- track manager
TP	- test personnel
Wh	- Watt hour

# 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 consisted 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 certified 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 consisted of a New Flyer of America, Inc. model XE40. The bus has a curbside front passenger door forward of the front axle and a curbside rear passenger door forward of the rear axle. The front passenger door is equipped with a New Flyer 32" wide bi-fold electric flip-out ramp. The bus is powered by a battery electric Siemens/DICO A5E40776737 propulsion control system coupled to a Siemens>IDB2022-INA06 A5E03279464 traction motor.

The measured curb weight was 11,720 lb. for the front axle and 22,320 lb. for the rear axle. These combined weights provided a total measured curb weight of 34,040 lb. There are 41 seats including the driver (or 35 seats and two wheelchairs) and free floor space for 41 standing passengers bringing the potential total passenger capacity to 82. However, a placard shows the maximum number of standing passengers as 28. Therefore, the gross load represents 41 seated passengers and 28 standees only, for a total of 69 passengers, including the driver. Gross load is calculated as 150 lb. x 69 = 10,350lb. At full declared capacity, the measured gross vehicle weight was 44,400 lb. The maximum seated load weight was obtained using the wheelchair positions. Seated load weight is calculated as (150 lb. x 35) + (600 lb. x 2) = 6,450 lb. There is a potential to overload this bus with the additional available floor space for standing passengers or when utilizing both wheelchair positions with maximum allowable standees.

# VEHICLE DATA FORM

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Bus Number: 1915-P	Date of Check-In: 12/03/19
Bus Manufacturer: New Flyer of America, Inc.	Vehicle Identification Number (VIN): 5FYB8FJ08HB051944
Model Number: XE40	Chassis Mfr./Mod. #: New Flyer/ XE40
Personnel: S.R. & E.D.	Starting Odometer Reading: 13,962

## WEIGHT:

### Individual Wheel Reactions:

Weights (lb.)	Front Axle		Middle Axle		Rear Axle	
	Curb	Street	Curb	Street	Curb	Street
CW	5,850	5,870	N/A	N/A	10,940	11,380
SLW	6,850	6,930	N/A	N/A	12,850	13,870
GVW	7,910	7,950	N/A	N/A	14,100	14,440

### Total Weight Details:

Weight (lb.)	CW	SLW	GVW	GAWR
Front Axle	11,720	13,780	15,860	15,873
Middle Axle	N/A	N/A	N/A	N/A
Rear Axle	22,320	26,720	28,540	28,660
Total	34,040	40,500	44,400	Manufacturer Specified GVWR: 44,533

### Dimensions:

Length (ft/in)	40 / 11 ½
Width (in)	101 ¾
Height (in)	132 ¾
Front Overhang (in)	88
Rear Overhang (in)	120 ¾
Wheelbase (in)	282 ¾
Wheel Track (in)	Front: 86 ¾ Middle: N/A Rear: 75 ½

# VEHICLE DATA FORM

Page 2 of 7

Bus Number: 1915-P	Date: 12/03/19
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## CLEARANCES:

Lowest Point Outside Front Axle	Location: Curbside skid plate	Clearance(in): 9.7
Lowest Point Outside Rear Axle	Location: Battery framework	Clearance(in): 11.5
Lowest Point between Axles	Location: Frame	Clearance(in): 10.1
Ground Clearance at the center (in)	10.1	
Front Approach Angle (deg)*	8.2	
Rear Approach Angle (deg)*	8.57	
Ramp Clearance Angle (deg)	4.0	
Aisle Width (in)	Front: 24.8	Rear: 24.3
Inside Standing Height at Center Aisle (in)	Front: 96.1	Rear: 79.4

\*measurements used to calculate approach and departure angles are taken from the centerline of the axles.

## BODY DETAILS:

Body Structural Type	Monocoque		
Frame Material	Steel		
Body Material	Aluminum and Composite		
Floor Material	Plywood		
Roof Material	Composite		
Windows Type	<input checked="" type="checkbox"/> Fixed	<input checked="" type="checkbox"/> Movable (Fixed with moveable tops)	
Window Mfg./Model No.	Arow / AS3DOT411 tempered		
Number of Doors	1	Front	1 Rear
Mfr. / Model No.	Front and Rear: Vapor Bus International / Slide Guide		
Dimension of Each Door (in)	Front: 78.0 x 33.7      Rear: 77.4 x 30.8		
Passenger Seat Type	<input checked="" type="checkbox"/> Cantilever	<input type="checkbox"/> Pedestal	<input type="checkbox"/> Other (explain)
Driver Seat Type	<input checked="" type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	USSC / 3PT G2A		
Number of Seats (including Driver)	41 or 35 and 2 wheelchairs		

# VEHICLE DATA FORM

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Bus Number: 1915-P	Date: 12/03/19
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## BODY DETAILS (Contd.)

Free Floor Space (ft <sup>2</sup> )	Seats: 67.8      Wheelchairs: 60.8			
Height of Each Step at Normal Position (in)	Front	1. 13.2	2. N/A	3. N/A
	Middle	1. N/A	2. N/A	3. N/A
	Rear	1. 13.9	2. N/A	3. N/A
Step Elevation Change - Kneeling (in)	Front: 4.3      Rear: 0.4			

## BATTERY SYSTEM

Maximum Rated Capacity (kWh)	480
Usable Capacity (kWh)	408
Nominal Voltage (Vdc)	618
Battery Chemistry	NMC (Lithium Manganese Cobalt Oxide)

## PROPULSION CONTROL SYSTEM (Rear Axle)

Propulsion Control System Mfr. / Model No.	Siemens / DICO A5E40776737
Traction Motor - Mfr. / Model No.	Siemens / IDB2022-INA06 A5E03279464
Traction Motor Power rating (kW)	210

## OTHERS

DCDC Converter Mfr. / Model No.	Vanner / EBA500-28-CAN
HV Distribution Box Mfr. / Model No.	Siemens / A5E40776735
Air Compressor	Powerex / SDCH050704-NF
Maximum Capacity (ft <sup>3</sup> /min)	12.1 cfm @125 psi

# VEHICLE DATA FORM

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Bus Number: 1915-P	Date: 12/03/19
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## SUSPENSION

Number of Axles	2		
Front Axle Type	<input type="checkbox"/> Independent	<input checked="" type="checkbox"/> Beam Axle	
Mfr. / Model No.	MAN Truck & Bus AG / VOK-07-F		
Axle Ratio (if driven)	N/A		
Suspension Type	<input checked="" type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Koni / 90-2517SPI		
Middle Axle Type	<input type="checkbox"/> Independent	<input type="checkbox"/> Beam Axle	
Mfr. / Model No.	N/A		
Axle Ratio (if driven)	N/A		
Suspension Type	<input type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	N/A		
Mfr. / Model No.	N/A		
Rear Axle Type	<input type="checkbox"/> Independent	<input checked="" type="checkbox"/> Beam Axle	
Mfr. / Model No.	MAN / 81353013111 / AGGHY1350F7 / FZ536524		
Axle Ratio (if driven)	5.67		
Suspension Type	<input checked="" type="checkbox"/> Air	<input type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	4		
Mfr. / Model No.	Front of Axle: Koni / 90 2518 SPI Rear of Axle: Koni / 90 2519 SPI		

# VEHICLE DATA FORM

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Bus Number: 1915-P	Date: 12/03/19
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## WHEELS & TIRES

Front	Wheel Mfr./ Model No.	Alcoa / 22.5 x 8.25
	Tire Mfr./ Model No.	Michelin / X Incity 305 70R 22.5
Rear	Wheel Mfr./ Model No.	Alcoa / 22.5 x 8.25
	Tire Mfr./ Model No.	Michelin / X Incity 305 70R 22.5

## BRAKES

Front Axle Brakes Type	<input type="checkbox"/> Cam	<input checked="" type="checkbox"/> Disc	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	Knorr / SN7000		
Middle Axle Brakes Type	<input type="checkbox"/> Cam	<input type="checkbox"/> Disc	<input type="checkbox"/> Other
Mfr. / Model No.	N/A		
Rear Axle Brakes Type	<input type="checkbox"/> Cam	<input checked="" type="checkbox"/> Disc	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	Knorr / SN7000		

## HVAC

Heating System Type	<input type="checkbox"/> Air	<input checked="" type="checkbox"/> Water -Front Dash	<input checked="" type="checkbox"/> Other - Electric		
Capacity (Btu/hr)	68,304				
Mfr. / Model No.	Spheros / Thermo DC / TE5M3 / Thermo DC 200				
Air Conditioner	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No			
Location	Rear (ThermoKing)				
Capacity (Btu/hr)	72,000				
A/C Compressor Mfr. / Model No.	Copeland – Scroll / ZR42K3E-TF5-130 & ZE61K3E-TF5-130				

## STEERING

Steering Gear Box Type	Hydraulic Assist		
Mfr. / Model No.	Sheppard / PN: M110		
Steering Wheel Diameter	18"		
Number of turns (lock to lock)	4.5		
Control Type	<input type="checkbox"/> Electric	<input checked="" type="checkbox"/> Hydraulic	<input type="checkbox"/> Other (explain)

## VEHICLE DATA FORM

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Bus Number: 1915-P	Date: 12/03/19
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### OTHERS

Wheelchair Ramps	Location: Front Passenger Door	Type: Bi-fold electric
Wheelchair Lifts	Location: N/A	Type: N/A
Mfr. / Model No.	New Flyer / 32" wide flip out ramp	
Emergency Exit	Location: Window Door Roof hatch	Number: 4 2 1

### CAPACITIES

Fuel Tank Capacity (gallons)	N/A
Engine Crankcase Capacity (gallons)	N/A
Transmission Capacity (gallons)	N/A
Differential Capacity (gallons)	3.8
Cooling System Capacity (gallons)	30.2 (total)
Power Steering Fluid Capacity (gallons)	4

## **VEHICLE DATA FORM**

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Bus Number: 1915-P Date: 12/03/19

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

**COMPONENT/SUBSYSTEM INSPECTION FORM**

Page 1 of 1

Bus Number: 1915-P	Date: 12/04/19
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Subsystem	Checked	Initials	Comments
Air Conditioning Heating and Ventilation	✓	S.R.	All electric systems.
Body and Sheet Metal	✓	S.R.	None noted.
Frame	✓	S.R.	None noted.
Steering	✓	S.R.	None noted.
Suspension	✓	S.R.	None noted.
Interior/Seating	✓	S.R.	None noted.
Axles	✓	S.R.	MAN axles front and rear.
Brakes	✓	S.R.	4 wheel disc brakes.
Tires/Wheels	✓	S.R.	None noted.
Exhaust	N/A	E.D.	No exhaust – Electric Bus.
Fuel System	✓	E.D.	Battery strings roof mounted.
Power Plant	✓	S.R.	Battery Electric.
Accessories	✓	E.D.	None noted.
ADA Accessible Lift System	N/A	E.D.	None noted.
ADA Accessible Ramp System	✓	E.D.	Electric bi-fold ramp at front entry door.
Interior Fasteners	✓	S.R.	None noted.
Batteries	✓	S.R.	None noted.

## CHECK - IN



**NEW FLYER OF AMERICA  
XE40**



## CHECK - IN CONT.



**NEW FLYER OF AMERICA  
XE40**



## CHECK - IN CONT.

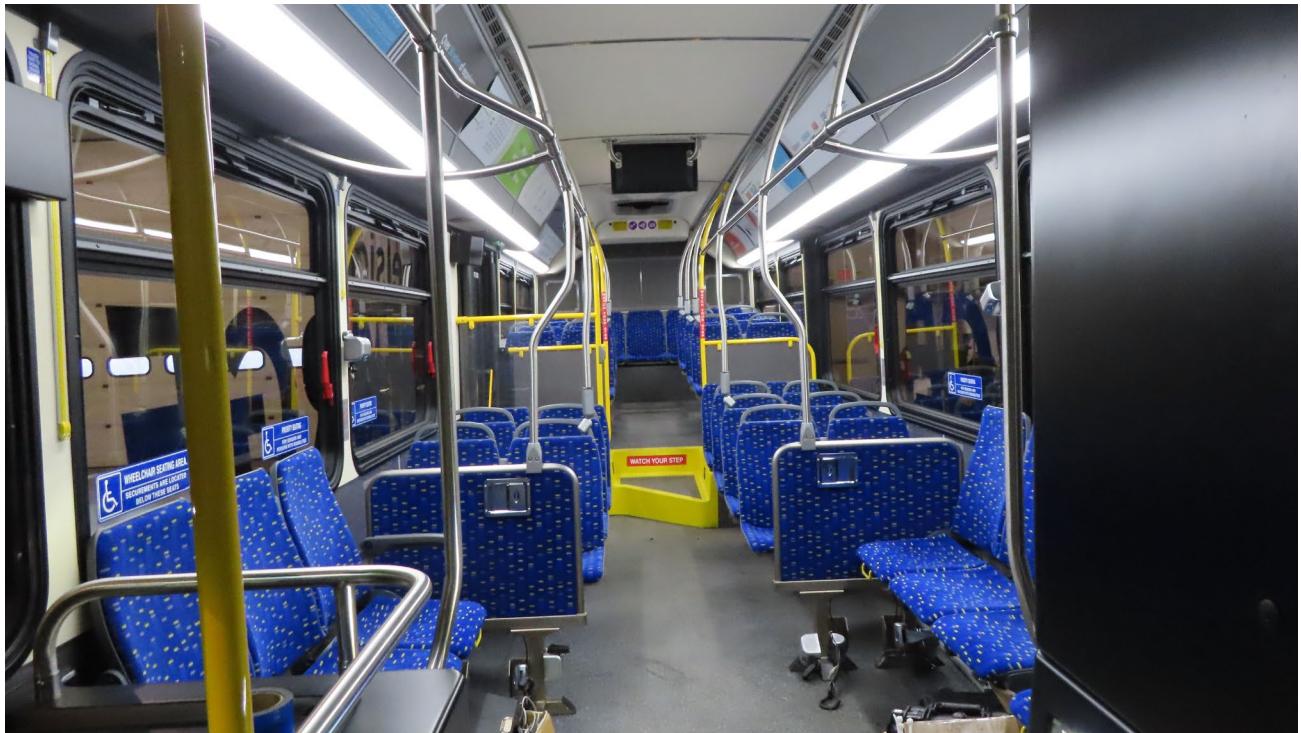


**NEW FLYER BI-FOLD ELECTRIC  
32" WIDE FLIP OUT RAMP**

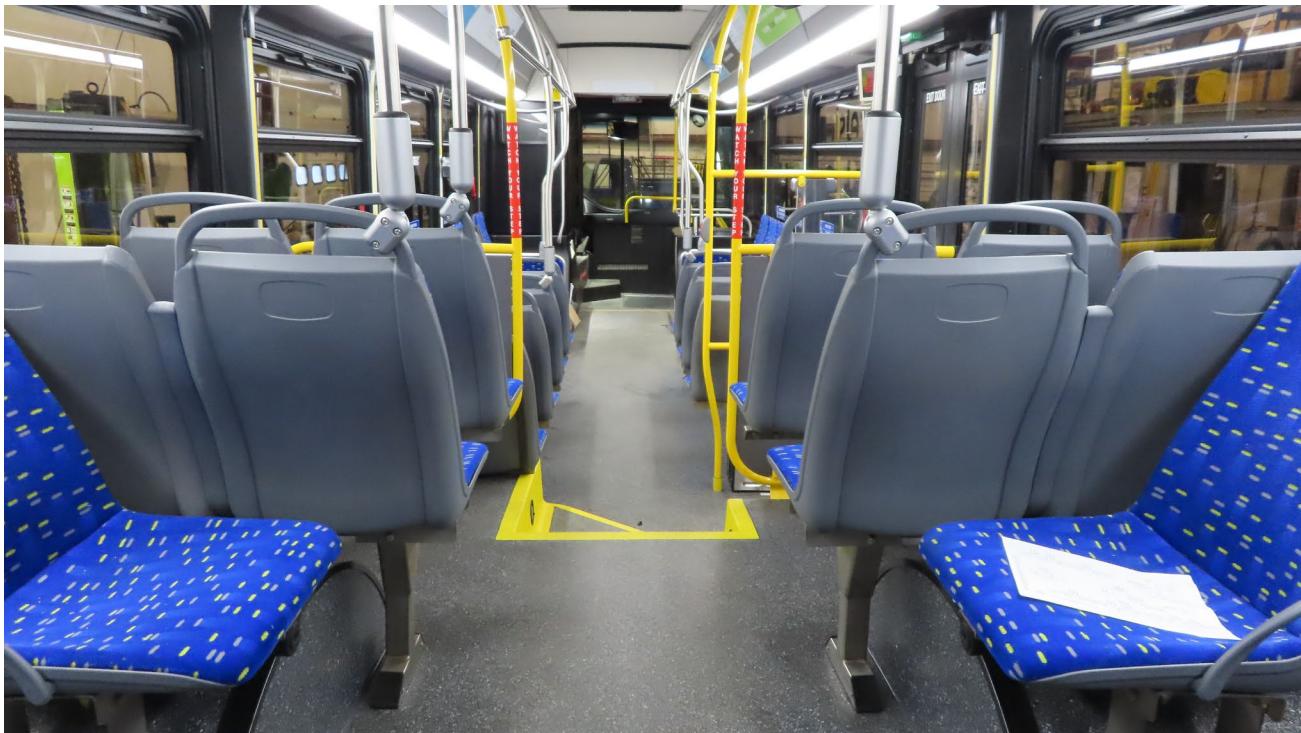


**OPERATOR'S AREA**

## CHECK - IN CONT.

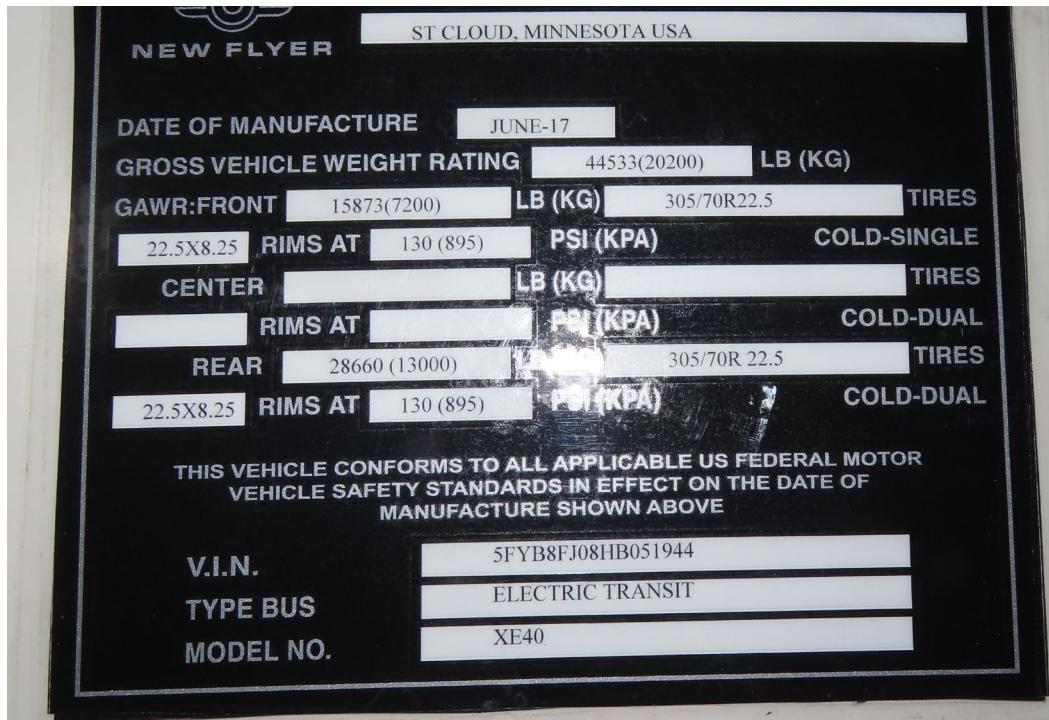


**INTERIOR FROM FRONT**



**INTERIOR FROM REAR**

## CHECK - IN CONT.



VIN TAG



PLACARD SHOWING MAXIMUM STANDEES

## CHECK - IN CONT.



BATTERIES ON ROOF



LOWER REAR POWERTRAIN COMPARTMENT

## CHECK - IN CONT.



**SIEMENS CHARGER**

## **1.2 SERVICING, PREVENTIVE MAINTENANCE, AND REPAIR AND MAINTENANCE DURING TESTING**

### **1.2-I. TEST OBJECTIVE**

The objective of this test is to collect maintenance data about the servicing, preventive maintenance, and repair.

### **1.2-II. TEST DESCRIPTION**

The test was conducted by operating the bus and collecting the following data on work order forms and a driver log.

- 1. Scheduled Maintenance**
  - a. Bus number
  - b. Date
  - c. Mileage
  - d. Results of scheduled inspections
  - e. Description of malfunction (if any)
  - f. Repair action and parts used (if any)
  - g. Man-hours required
- 2. Unscheduled Maintenance**
  - a. Bus number
  - b. Date
  - c. Mileage
  - d. Description of malfunction
  - e. Place and time of malfunction (e.g., in service or undergoing inspection)
  - f. Repair action and parts used
  - g. Man-hours required

The bus was operated in accelerated durability service. While typical items are given below, the specific service schedule was that specified by the manufacturer.

- A. Service**
  1. Fueling/Charging
  2. Consumable checks
  3. Interior cleaning
- B. Preventive Maintenance**
  1. Brake adjustments
  2. Lubrication
  3. 3,000 mi (or manufacturer recommended) inspection

4. Oil and filter change inspection (If applicable)
  5. Major inspection
- C. Periodic Repairs
1. Brake reline\*
  2. Drive motor/Transmission change
  3. Engine change\*
  4. Windshield wiper motor change
  5. Stoplight bulb change\*
  6. Towing operations
  7. Hoisting operations

\*These items are attended to if found necessary, while the others in the list are removed/replaced/tested for all buses undergoing a full test.

### 1.2-III. DISCUSSION

Servicing and preventive maintenance were performed at manufacturer-specified intervals. The following Scheduled Maintenance Form lists the mileage, items serviced, the service interval, and amount of time required to perform the maintenance.

The Unscheduled Maintenance List along with related photographs is included in Section 5.7, Structural Durability. This list supplies information related to failures that occurred during the durability portion of testing. The Unscheduled Maintenance List includes the date and mileage at which the malfunction was detected, a description of the malfunction and repair, and the time required to perform the repair.

**SCHEDULED MAINTENANCE**  
 New Flyer Bus# 1915-P  
 (Page 1 of 3)

DATE	TEST MILES	SERVICE	ACTIVITY/OBSERVATIONS	DOWN TIME	LABOR HOURS
02/04/20	694	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.	4.00	4.00
			Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.		
02/21/20	2,150	P.M./Inspection	Notes: Top outside corner of curbside windshield is coming out of the rubber seal. There is damage to the left, front corner fiberglass between the bumper and the compartment door.	4.00	4.00
			Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.		
03/19/20	3,452	P.M./Inspection	Notes: The rear roof hatch shattered when the bus manufacturer's representative opened it. It cracked when flipped backward and impacted the HV enclosure behind it.	4.00	4.00
			Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.		
07/16/20	3,732	P.M./Inspection	Notes: Front, curbside sway bar D-bushing is showing wear.	4.00	4.00
			Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.		
08/11/20	5,316	P.M./Inspection	Notes: Windshield is moving out of weather strip – upper left corner.	4.00	4.00

**SCHEDULED MAINTENANCE**  
 New Flyer Bus# 1915-P  
 (Page 2 of 3)

DATE	TEST MILES	SERVICE	ACTIVITY/OBSERVATIONS	DOWN TIME	LABOR HOURS
08/19/20	6,328	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension. Notes: Latch missing on street-side compartment on ceiling above wheel wells. Top right windshield glass is pulling away from gasket.	4.00	4.00
08/28/20	7,483	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension. Notes: Replaced front sway bar and D-bushings per manufacturer's service plan. Uneven wear on steer tires.	4.00	4.00
11/05/20	8,799	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension. Notes: All driver's controls were set for heat, but bus was blowing cold air. Shut bus off for one hour, and when bus was started, it began blowing hot air.	4.00	4.00
11/25/20	9,770	P.M./Inspection Energy Economy	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.  Notes: Cracks in K-member forward of the rear axle are being monitored. They do not appear to be spreading. Per manufacturer, front sway bar is being replaced at this preventative maintenance interval.	8.00	8.00

**SCHEDULED MAINTENANCE**  
 New Flyer Bus# 1915-P  
 (Page 3 of 3)

DATE	TEST MILES	SERVICE	ACTIVITY/OBSERVATIONS	DOWN TIME	LABOR HOURS
01/22/21	11,023	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.  Notes: Bus was hard to start. The roof is cracking in panels on both sides above the front tires. The roof panel is cracked by the roof access door.	4.00	4.00
01/28/21	11,236	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.	4.00	4.00
02/26/21	12,261	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.  Note: Hydraulic electric steering pump isolators are worn out.	4.00	4.00
03/17/21	13,267	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.	4.00	4.00
03/29/21	14,384	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.  Note: The windshield is leaking on the driver's side.	4.00	4.00
04/08/21	15,550	P.M./Inspection	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension.	4.00	4.00

## **2. RELIABILITY - DOCUMENTATION OF BREAKDOWN AND REPAIR TIMES DURING TESTING**

### **2-I. TEST OBJECTIVE**

The objective of this test is to document unscheduled breakdowns, repairs, down time, and repair time that occur during testing.

### **2-II. TEST DESCRIPTION**

Using the driver log and unscheduled work order forms, all significant breakdowns, repairs, labor-hours to repair, and hours out of service were recorded on the Reliability Data Form.

### **CLASS OF FAILURES**

Classes of failures are described below:

- (a) Class 1: Physical Safety. A failure that could lead directly to Injury, a crash and/or significant physical damage.
- (b) Class 2: Road Call. A failure resulting in an en-route interruption of revenue service. Service is discontinued until the bus is replaced or repaired at the point of failure.
- (c) Class 3: Bus Change. A failure that requires removal of the bus from service during its assignments. The bus is operable to a rendezvous point with a replacement bus.
- (d) Class 4: Bad Order. A failure that does not require removal of the bus from service during its assignments but does degrade coach operation. The failure shall be reported by driver, inspector, or hostler.

### **2-III. DISCUSSION**

A listing of breakdowns and unscheduled repairs was accumulated during the Structural Durability Test. The following Reliability Data Form lists all unscheduled repairs under classes as defined above.

The classification of repairs according to subsystem is intended to emphasize those systems which had persistent minor or more serious problems. There were 52 reported failures. Seven of the failures were Class 4, 41 were Class 3, two were Class 2 and two were Class 1. These failures occurred throughout various subsystems. The two Class 1 failures are related to each other and have been deemed corrected. These failures are available for review in the Unscheduled Maintenance List, located in Section 5.7 Structural Durability.

**RELIABILITY DATA FORMS**

Bus Number: 1915-P	Date: 08/12/2021
Personnel: B.L.	

Subsystems	Failure Type				Labor Hours	Down Time
	Class 4 Bad Order	Class 3 Bus Change	Class 2 Road Call	Class 1 Physical Safety		
Electrical		506			---	---
	2,602				1.00	1.00
		5,923			1.50	1.50
		8,494			0.25	0.25
		8,608			0.10	0.10
		9,722			0.50	0.50
		9,772			0.05	0.05
		11,498			0.05	0.05
Powertrain				702	0.50	0.50
				2,602	2.80	2.80
			2,629		0.50	0.50
Body	1,114				---	---
		7,887			0.50	0.50
		12,261			0.25	0.25
		13,267			0.10	0.10
Suspension		1,132			2.00	2.00
		2,291			0.50	0.50
		2,331			1.25	1.25
		2,350			1.00	1.00
		2,549			1.00	1.00
	2,629				0.50	0.50
		2,726			0.50	0.50
		3,638			0.50	0.50

**RELIABILITY DATA FORMS**

Bus Number: 1915-P	Date: 08/12/2021
Personnel: B.L.	

Subsystems	Failure Type				Labor Hours	Down Time
	Class 4 Bad Order	Class 3 Bus Change	Class 2 Road Call	Class 1 Physical Safety		
Suspension (cont.)		4,024			1.50	1.50
		4,866			0.50	0.50
		5,316			1.00	1.00
		6,328			1.00	1.00
		7,977			1.00	1.00
		8,331			1.50	1.50
		8,799			2.00	2.00
		9,036			0.50	0.50
		9,097			1.00	1.00
		11,763			1.00	1.00
		11,937			1.00	1.00
		12,262			1.00	1.00
A/C		14,384			0.50	0.50
		14,384			2.50	2.50
		1,132			0.10	0.10
		3,732			2.00	2.00
		3,762			1.00	1.00
Frame		4,252			2.00	2.00
		4,866			3.00	3.00
Hardware		7,977			36.00	36.00
		15,075			5.00	5.00
Hardware		9,770			1.00	1.00

**RELIABILITY DATA FORMS**

Bus Number: 1915P	Date: 08/12/2021
Personnel: B.L.	

Subsystems	Failure Type				Labor Hours	Down Time
	Class 4 Bad Order	Class 3 Bus Change	Class 2 Road Call	Class 1 Physical Safety		
Electrical/Cooling		11,023			1.00	1.00
		11,418			1.00	1.00
Coolant (Battery)			11,529		0.50	0.50
Lighting		12,261			1.00	1.00
Electrical/Charging		12,918			0.10	0.10
Suspension/Steering		13,267			1.00	1.00
Body/Glass		13,394			0.50	0.50

## **3.1 SAFETY - A DOUBLE-LANE CHANGE (OBSTACLE AVOIDANCE)**

### **3.1-I. TEST OBJECTIVE**

The objective of this test is to determine handling and stability of the bus by measuring speed through a double lane change test.

### **3.1-II. TEST DESCRIPTION**

The Safety Test consisted of an obstacle avoidance maneuver to evaluate the handling and stability of the bus. The test was conducted at the LTI test track on the vehicle dynamics pad. The bus was driven through a double-lane change course at increasing speeds until the test was determined to be unsafe or a speed of 45 mph is reached. The test is determined unsafe if vehicle handling becomes unstable or if any of the tires lose contact with the pavement.

The layout of the test course was defined by placing pylons along painted guidelines that delineated the course. The guidelines marked off two 12-foot center-to-center lanes. Each lane had two 100 foot long gates with a spacing distance of 100 feet between them. The bus entered the test course in one lane, crossed over to the other lane within the 100 foot gate, traveled for 100 feet, and then returned back into the original lane within the next 100 foot gate. This maneuver was repeated from 20 mph with speed increasing in increments of 5 mph. The test was performed starting from both the right and left lanes.

A test run is considered valid if the bus is able to perform the maneuver at a constant speed without deviating from the test course or striking pylons. If the bus is not able to successfully complete the maneuver due to vehicle instability, the test will be terminated. The highest speed at which the maneuver can be successfully performed up to a maximum speed of 45 mph is recorded on the Safety Data Form.

### **3.1-III. DISCUSSION**

The double-lane change was performed in both right-hand and left-hand directions. The bus was able to safely negotiate the test course in both the right-hand and left-hand directions up to the maximum test speed of 45 mph.

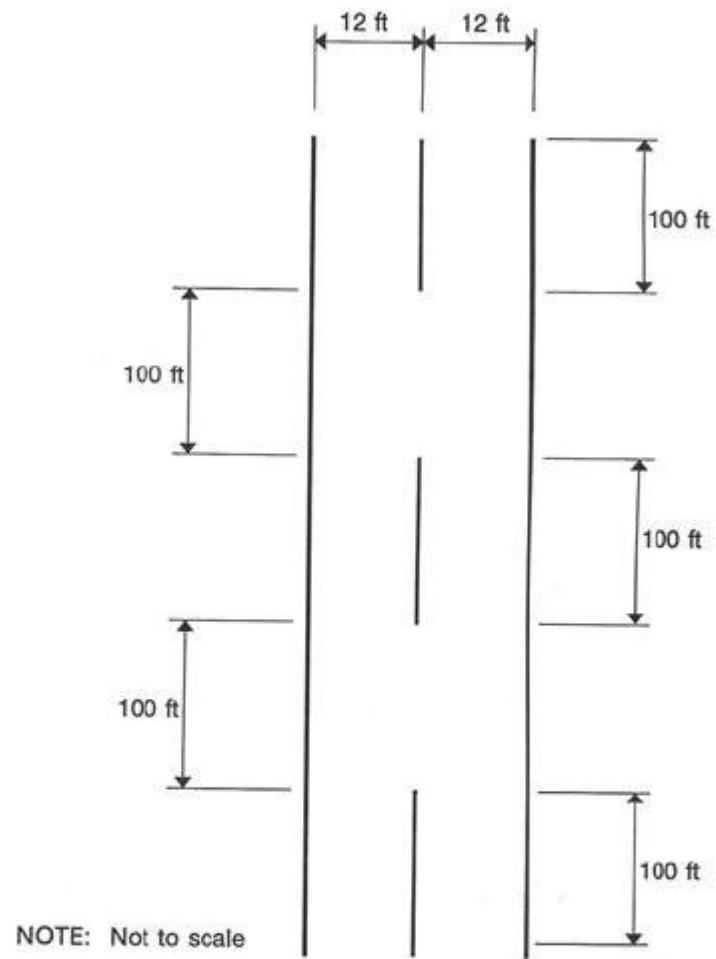


Figure 3.1. Double lane change test course

## **SAFETY DATA FORM**

Page 1 of 1

Bus Number: 1915-P	Date: 11/10/2020
Personnel: S.R., E.D. & M.H.	

Temperature (°F): 61	Humidity (%): 79
Wind Direction: NW	Wind Speed (mph): 2
Barometric Pressure (inHg): 30.17	

<b>SAFETY TEST: DOUBLE LANE CHANGE</b>	
Maximum safe speed tested for double-lane change to left	45 mph
Maximum safe speed tested for double-lane change to right	45 mph
<b>Comments of the position of the bus during the lane change:</b>	
The test vehicle appeared to maintain a safe profile throughout the test. The driver noted that the rear end felt "loose" in the transition areas of the course at 40 - 45 mph.	
<b>Comments of the tire/ground contact patch:</b>	
The vehicle maintained the tire/ground patch throughout all portions of testing.	

### 3.1 SAFETY



**RIGHT - HAND APPROACH**



**LEFT - HAND APPROACH**

## **4. 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 was operated at SLW on a chassis dynamometer. The procedure dictates that the test bus be accelerated to a maximum "power-limited"/"governed" or maximum "safe" speed not exceeding 80 mph. The maximum power-limited/governed speed, if applicable, is the top speed as limited by the engine control system. The maximum safe speed is defined as the maximum speed that the dynamometer, the tires or other bus components are limited to. The test vehicle speed was measured using a speed encoder built in the chassis dynamometer. The time intervals between 10 mph increments were recorded using a Data Acquisitions System. Time-speed data and the top speed attained were recorded on the Performance Data Form. The recorded data was used to generate a percent grade versus speed table and a speed versus time curve. All the above are available in the following pages.

### **4-III. DISCUSSION**

This test consisted of three runs from standstill to full throttle on the chassis dynamometer. Speed versus time data was obtained for each run and results are averaged to minimize test variability. The test was performed up to a maximum governed speed of 61.4 mph. The calculated gradeability results are attached. The average time to reach 30 mph was 14.6 seconds. The maximum gradeability at 10 mph was 12.55% and at 40 mph was 5.16%.

Since the Siemens charger provided by the manufacturer was not portable, a portable Charge Point charger was used for the performance test.

# PERFORMANCE DATA FORM

Page 1 of 1

Bus Number: 1915-P	Date: 12/16/2020		
Personnel: F.T. & S.I.			
Temperature (°F): 67.2	Humidity (%): 13.0		
Barometric Pressure (inHg): 29.0			
		<b>INITIALS:</b>	
Air Conditioning - OFF	<input checked="" type="checkbox"/> Checked	F.T.	
Ventilation fans - ON HIGH	<input checked="" type="checkbox"/> Checked	F.T.	
Heater pump motor - OFF	<input checked="" type="checkbox"/> Checked	F.T.	
Defroster - OFF	<input checked="" type="checkbox"/> Checked	F.T.	
Exterior and interior lights - ON	<input checked="" type="checkbox"/> Checked	F.T.	
Windows and doors - CLOSED	<input checked="" type="checkbox"/> Checked	F.T.	
<b>ACCELERATION, GRADEABILITY, TOP SPEED</b>			
Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph	3.1	3.1	3.3
20 mph	8.0	8.0	8.3
30 mph	14.4	14.6	14.8
40 mph	21.9	22.1	22.3
50 mph	32.6	32.7	32.9
60 mph	48.4	48.4	48.7
70 mph	N/A	N/A	N/A

Maximum Speed (mph): 61.4 (maximum governed speed reached)

# PERFORMANCE SUMMARY SHEET

Bus Number: 1915-P	Date: 12/16/2020
Personnel: F.T. & S.I.	

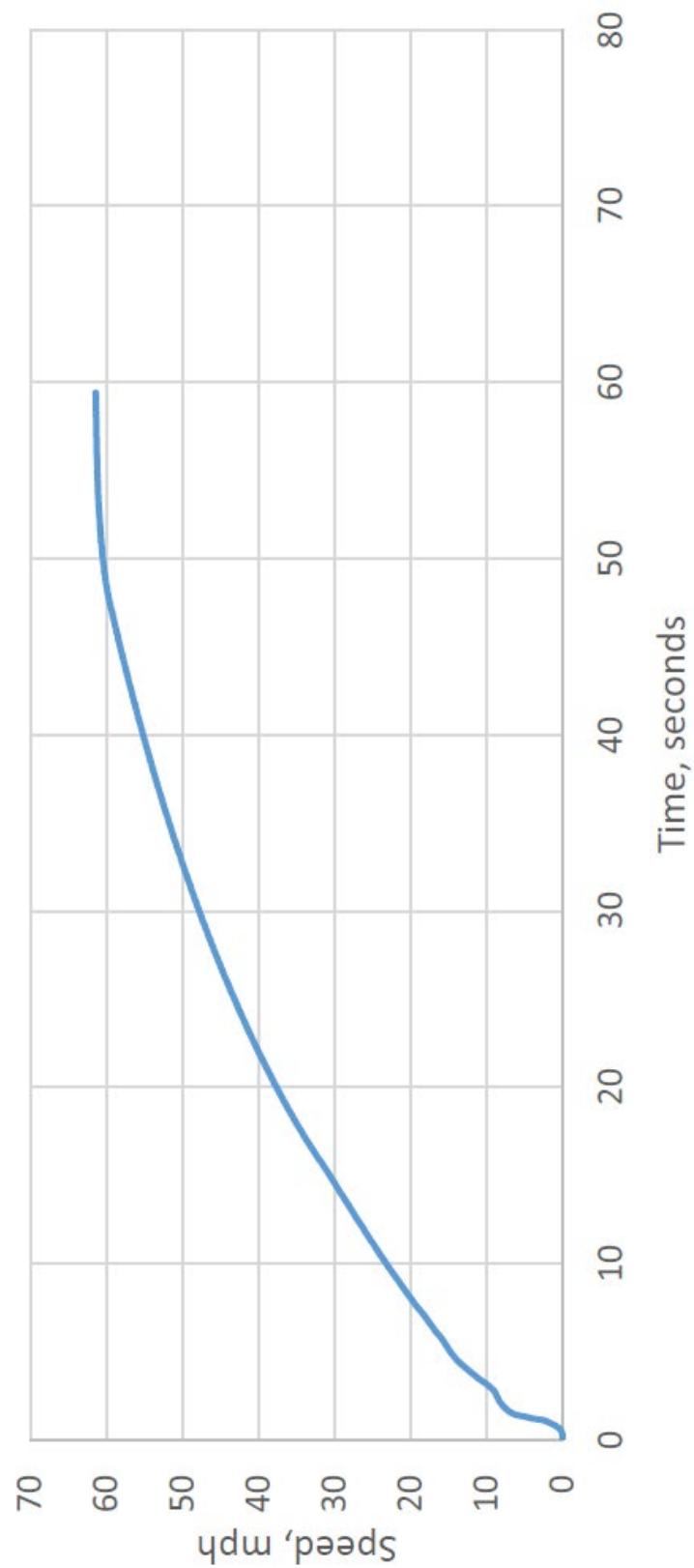
## Test Conditions:

Temperature (°F): 67.2	Humidity (%): 13.0
Barometric Pressure (inHg): 29.0	

## Test Results:

Vehicle Speed (MPH)	Time (SEC)	Acceleration (FT/SEC^2)	Max. Grade (%)
1.0	0.8	7.27	22.59
5.0	1.3	9.19	28.56
10.0	3.2	4.04	12.55
15.0	5.2	2.37	7.36
20.0	8.1	2.49	7.74
25.0	11.2	2.29	7.12
30.0	14.6	2.11	6.56
35.0	18.0	1.99	6.18
40.0	22.1	1.66	5.16
45.0	26.9	1.39	4.32
50.0	32.7	1.12	3.48
55.0	39.7	0.96	2.98
60.0	48.5	0.53	1.65
61.4	59.4	Maximum Speed	

### New Flyer Bus# 1915-P



## **5.7 STRUCTURAL DURABILITY TEST**

### **5.7-I. TEST OBJECTIVE**

The objective of this test is to perform an accelerated durability test that approximates 25 percent of the service life of the vehicle.

### **5.7-II. TEST DESCRIPTION**

The test vehicle was driven a total of 19,110 miles; approximately 16,476 miles on the LTI Durability Test Track and approximately 2,634 miscellaneous other miles. These miles include additional miles that the FTA required in order to prove the repairs of the two class one failures. The test was conducted with the bus operated under three different loading conditions. The first segment consisted of approximately 6,250 miles with the bus operated at GVW. The second segment consisted of approximately 2,500 miles with the bus operated at SLW. The remainder of the test, approximately 6,250 miles, was conducted with the bus loaded to CW. Once these miles were completed, the bus ran an additional 2,625 miles at GVW and 350 miles at SLW to demonstrate the repairs to the frame were adequate and an additional 1,000 miles at SLW to validate the update to the powertrain software. The loads on both axles and GVW were within their ratings with the bus loaded as specified by the manufacturer. All subsystems were running during these tests in their normal operating modes. All manufacturer-recommended servicing was followed and noted on the vehicle maintainability log. Servicing items accelerated by the durability tests were compressed by 10:1; all others were done on a 1:1 mi/mi basis. Unscheduled breakdowns and repairs were recorded on the same log as are any unusual occurrences as noted by the driver. Once a week the test vehicle was washed down and thoroughly inspected for any signs of failure.

### **5.7-III. DISCUSSION**

The Structural Durability Test was started on December 17, 2019 and was conducted until July 20, 2021. The first 6,250 miles were performed at a GVW of 44,400 lb. and completed on August 21, 2020. The next 2,500-mile SLW segment was performed at 40,500 lb. and completed on November 10, 2020 and the final 6,250-mile segment was performed at a CW of 34,040 lb. and completed on April 6, 2021.

The FTA determined that this bus was to run an additional 2,625 miles at GVW, which started on April 6, 2021, and completed on May 11, 2021, and 350 miles at SLW, which started on May 11, 2021 and completed on May 13, 2021. These additional miles were required to demonstrate that the repair made to the frame on October 28, 2020, adequately corrected the issue. No additional cracking was noticed, and this failure is deemed to be corrected.

Further, the FTA required that the bus run an additional 1,000 miles in order to validate the repair that was made to prevent the bus from entering an uncommanded reverse. The additional 1,000 miles were performed at SLW. These additional miles started on July 6, 2021 and were completed on July 20, 2021. No additional uncommanded reverse events occurred during these additional miles; therefore, these two related Class 1 failures are deemed corrected.

A Siemens charger was provided by the manufacturer when the bus was submitted for testing. On several occasions throughout the test, this bus had charging issues. These included the charger not recognizing the bus once connected, the bus was unable to charge, and occasionally the bus did not charge to 100% state of charge. The manufacturer's representative made multiple attempts to correct the issue, including installing software updates to the charger. Since the charger used for this bus is not proprietary to the bus, no unscheduled maintenance hours were counted for these repairs and details of the repairs to the charger are not included in this report. However, the details of the issues can be found in a table after the unscheduled maintenance repairs.

The following mileage summary presents the accumulation of miles during the Structural Durability Test. The driving schedule is included, showing the operating duty cycle. A detailed plan view of the LTI Test Track Facility and Durability Test Track are attached for reference. Also, a durability element profile detail shows all the measurements of the different conditions. Finally, photographs illustrating some of the failures that were encountered during the Structural Durability Test are included. There were no uncorrected Class 1 or more than two uncorrected Class 2 failures, and the unscheduled maintenance of 86.55 hours was less than 125 hours.

New Flyer Bus # 1915-P  
MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
12/16/20 TO 12/22/20	0.00	67.00	67.00
12/23/20 TO 12/29/20	0.00	0.00	0.00
12/30/20 TO 01/05/20	0.00	0.00	0.00
01/06/20 TO 01/12/20	0.00	0.00	0.00
01/13/20 TO 01/19/20	0.00	78.00	78.00
01/20/20 TO 01/26/20	0.00	48.00	48.00
01/27/20 TO 02/02/20	196.00	8.00	204.00
02/03/20 TO 02/09/20	394.00	19.00	413.00
02/10/20 TO 02/16/20	271.00	13.00	284.00
02/17/20 TO 2/23/2020	953.00	42.00	995.00
02/24/20 TO 03/01/20	314.00	17.00	331.00
03/02/20 TO 03/08/20	51.00	2.00	53.00
03/09/20 TO 03/15/20	253.00	20.00	273.00
03/16/20 TO 03/22/20	551.00	24.00	575.00
<b>ALL TESTING AT THE ALTOONA BUS TESTING CENTER WAS SUSPENDED FROM 03/26/20 TO 07/16/20 DUE TO THE COVID-19 PANDEMIC</b>			
07/13/20 TO 7/19/2020	652.00	161.00	813.00

New Flyer Bus # 1915-P  
MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
07/20/20 TO 07/26/20	0.00	0.00	0.00
07/27/20 TO 08/02/20	470.00	75.00	545.00
08/03/20 TO 08/09/20	89.00	117.00	206.00
08/10/20 TO 08/16/20	873.00	140.00	1013.00
08/17/20 TO 08/23/20	229.00	168.00	397.00
08/24/20 TO 08/30/20	932.00	194.00	1126.00
08/31/20 TO 09/06/20	398.00	69.00	467.00
09/07/20 TO 09/13/20	0.00	0.00	0.00
09/14/20 TO 09/20/20	0.00	0.00	0.00
09/21/20 TO 09/27/20	0.00	0.00	0.00
09/28/20 TO 10/04/20	0.00	0.00	0.00
10/05/20 TO 10/11/20	0.00	0.00	0.00
10/12/20 TO 10/18/20	0.00	147.00	147.00
10/19/20 TO 10/25/20	0.00	0.00	0.00
10/26/20 TO 11/01/20	106.00	51.00	157.00

## New Flyer Bus # 1915-P

## MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
11/02/20 TO 11/08/20	518.00	19.00	537.00
11/09/20 TO 11/15/20	155.00	63.00	218.00
11/16/20 TO 11/22/20	489.00	20.00	509.00
11/23/20 TO 11/29/20	109.00	105.00	214.00
11/30/20 TO 12/06/20	187.00	60.00	247.00
12/07/20 TO 12/13/20	232.00	57.00	289.00
12/14/20 TO 12/20/20	0.00	249.00	249.00
12/21/20 TO 12/27/20	0.00	0.00	0.00
12/28/20 TO 01/03/21	0.00	0.00	0.00
01/04/21 TO 01/10/21	0.00	0.00	0.00
01/11/21 TO 01/17/21	35.00	1.00	36.00
01/18/21 TO 01/24/21	355.00	109.00	464.00
01/25/21 TO 01/31/21	249.00	10.00	259.00
02/01/21 TO 02/07/21	84.00	4.00	88.00
02/08/21 TO 02/14/21	239.00	11.00	250.00

New Flyer Bus # 1915-P  
MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
02/15/21 TO 02/21/21	459.00	20.00	479.00
02/22/21 TO 02/28/21	105.00	5.00	110.00
03/01/21 TO 03/07/21	162.00	8.00	170.00
03/08/21 TO 03/14/21	496.00	22.00	518.00
3/15/21 TO 03/21/21	500.00	21.00	521.00
03/22/21 TO 03/28/21	701.00	30.00	731.00
03/29/21 TO 04/04/21	636.00	26.00	662.00
04/05/21 TO 04/11/21	466.00	116.00	582.00
04/12/21 TO 04/18/21	531.00	24.00	555.00
04/19/21 TO 04/25/21	605.00	26.00	631.00
4/26/2021 TO 05/02/21	319.00	20.00	339.00
05/03/21 TO 05/09/21	488.00	22.00	510.00
05/10/21 TO 05/16/21	630.00	125.00	755.00
05/17/21 TO 05/23/21	0.00	0.00	0.00
05/24/21 TO 05/30/21	0.00	0.00	0.00

New Flyer Bus # 1915-P  
MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
05/31/21 TO 06/06/21	0.00	0.00	0.00
06/07/21 TO 06/13/21	0.00	0.00	0.00
06/14/21 TO 06/20/21	0.00	0.00	0.00
06/21/21 TO 06/27/21	0.00	0.00	0.00
06/28/21 TO 07/04/21	0.00	0.00	0.00
07/05/21 TO 07/11/21	707.00	0.00	707.00
07/12/21 TO 07/18/21	0.00	0.00	0.00
07/19/21 TO 07/25/21	287.00	1.00	288.00
<b>Total</b>	<b>16476.00</b>	<b>2634.00</b>	<b>19110.00</b>

Driving Schedule for Bus Operation on the Durability Test Track.

STANDARD OPERATING SCHEDULE

Monday through Friday

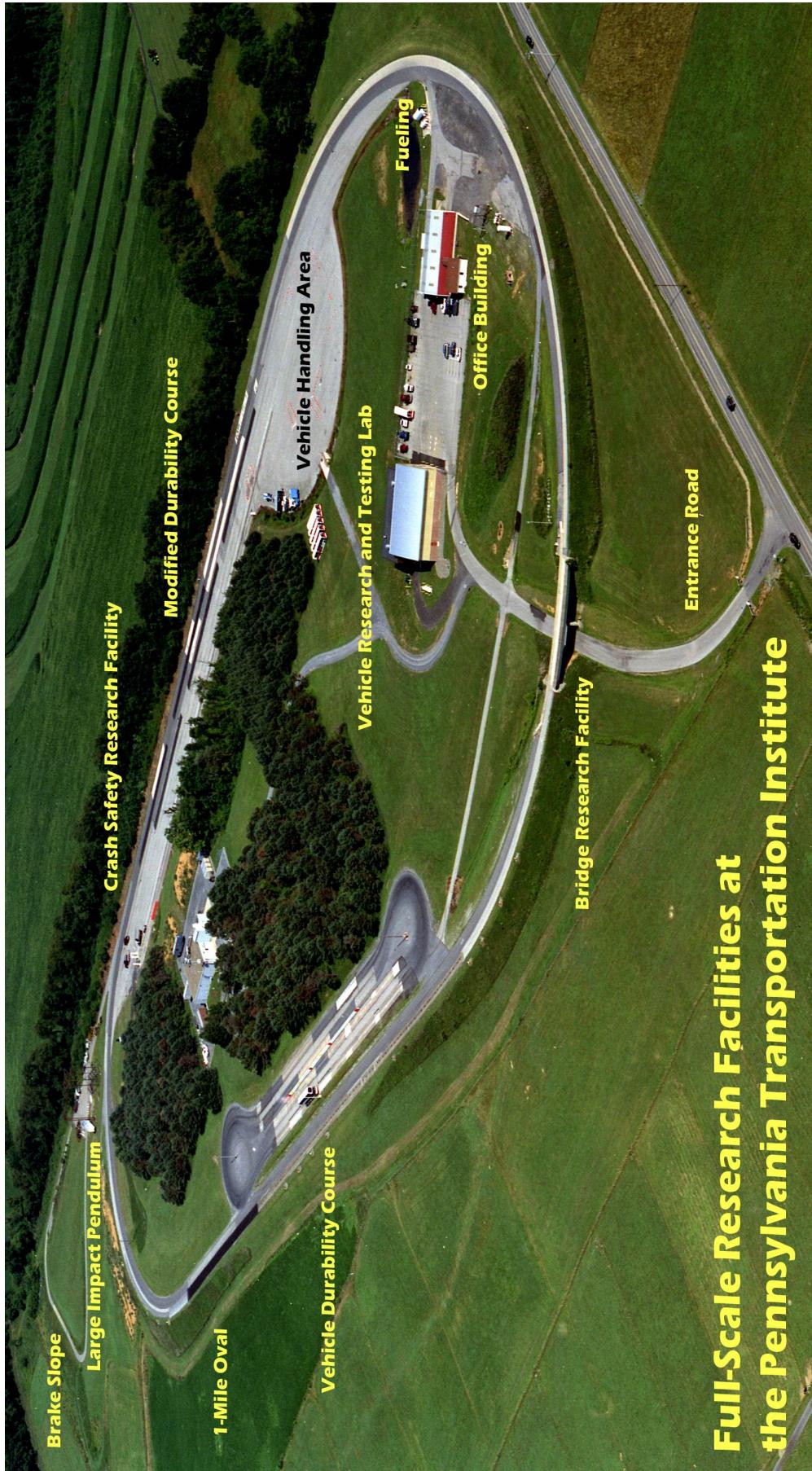
	HOUR	ACTION
Shift 1	midnight	D
	1:40 am	C
	1:50 am	B
	2:00 am	D
	3:35 am	C
	3:45 am	B
	4:05 am	D
	5:40 am	C
	5:50 am	B
	6:00 am	D
	7:40 am	C
	7:50 am	F
	8:00 am	D
	9:40 am	C
Shift 2	9:50 am	B
	10:00 am	D
	11:35 am	C
	11:45 am	B
	12:05 pm	D
	1:40 pm	C
	1:50 pm	B
	2:00 pm	D
	3:40 pm	C
	3:50 pm	F
	4:00 pm	D
	5:40 pm	C
	5:50 pm	B
	6:00 pm	D
Shift 3	7:40 pm	C
	7:50 pm	B
	8:05 pm	D
	9:40 pm	C
	9:50 pm	B
	10:00 pm	D
	11:40 pm	C
	11:50 pm	F

B—Break

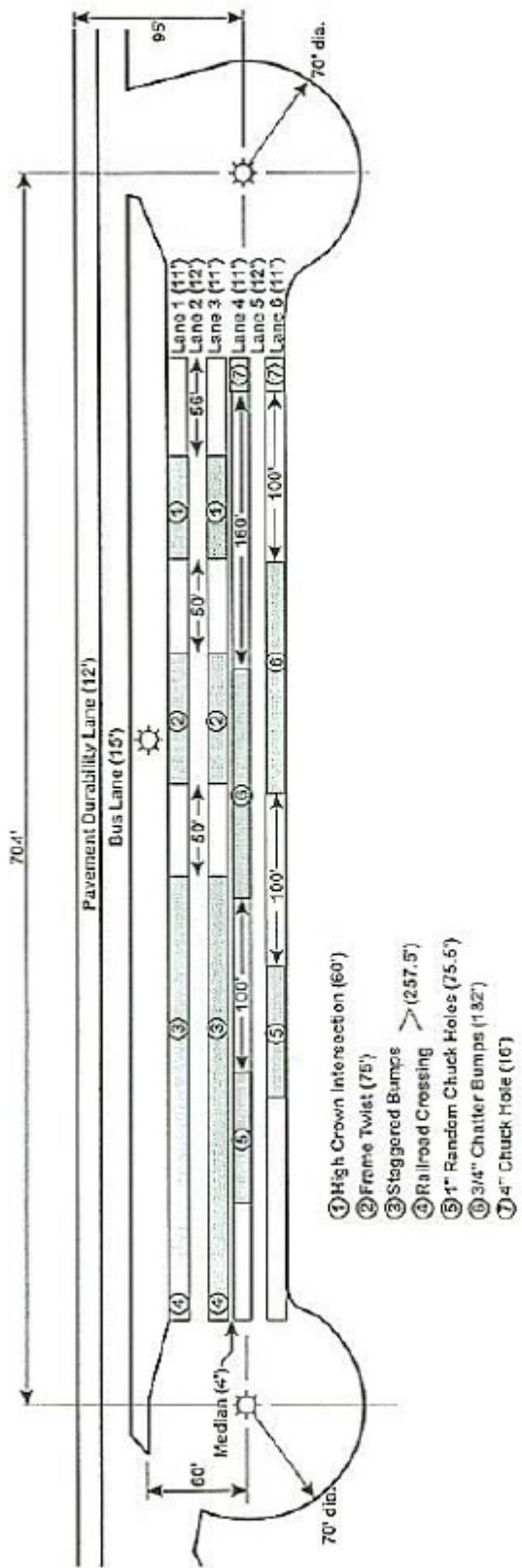
C---Cycle all systems five times, visual inspection, driver's log entries

D—Drive bus as specified by procedure

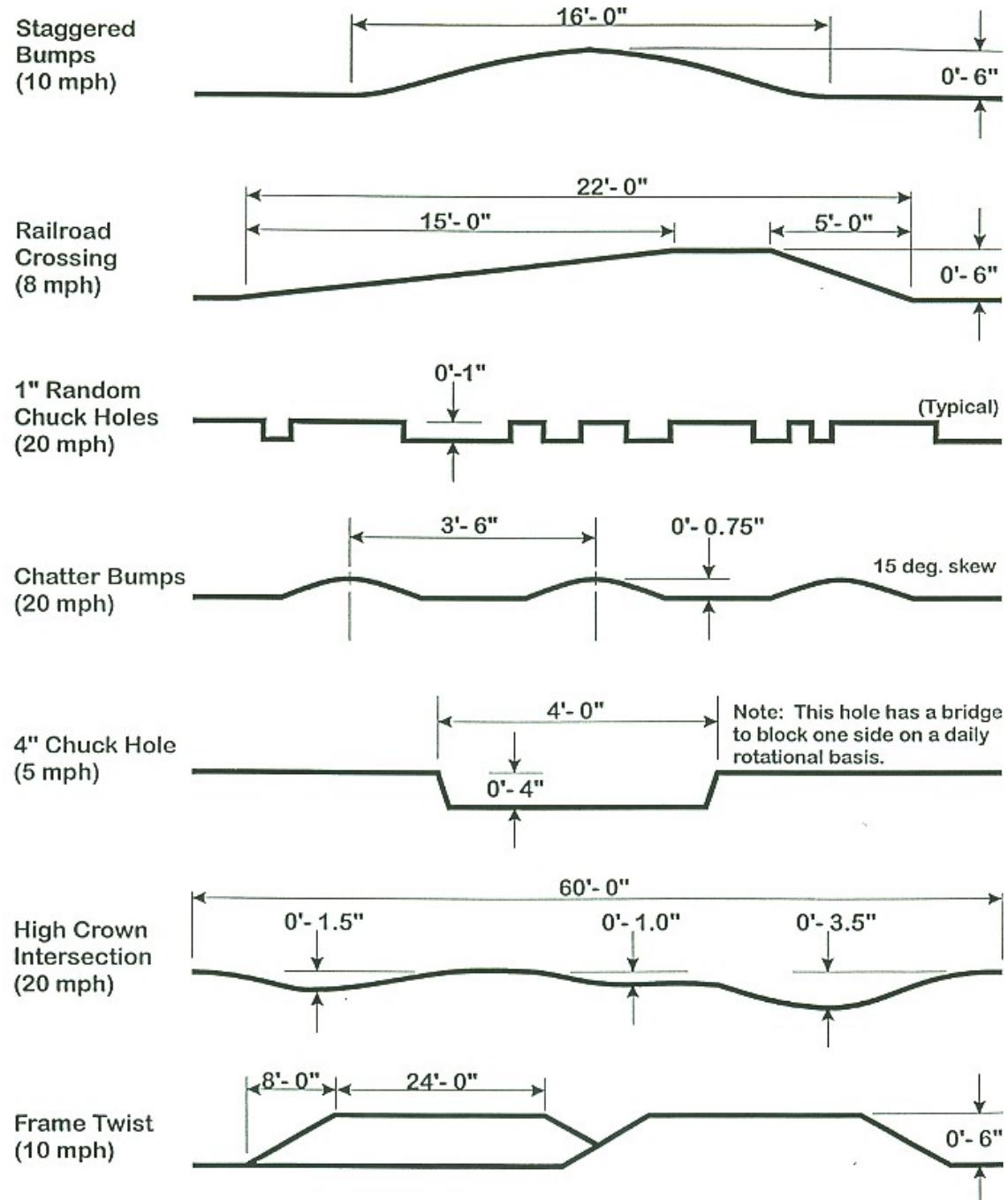
F---Fuel bus, complete driver's log shift entries



**Full-Scale Research Facilities at  
the Pennsylvania Transportation Institute**



Plan View  
**Vehicle Durability Test Track**  
 Track 1 (Track 2 has similar layout)  
 The Larson Transportation Institute  
 Penn State



## Durability Element Profiles

The Pennsylvania Transportation Institute  
Penn State

Unscheduled Maintenance  
New Flyer Bus# 1915-P  
(Page 1 of 7)

Date	Test Miles	Issue	Action	Labor Hours	Sub-system	Class
01/30/20	506	Cannot adjust mirrors from driver's seat.	Not attended to	---	Electrical	3
02/04/20 To 02/11/20	702 To 926	Red Check system and red stop system lights came on. Cycled 24 v system bus would start to move then go into reverse.	Bus Manufacturer's representative read error codes, checked and replaced connectors on encoder cable from the motor to inverter. This issue reoccurred and was deemed corrected – See related entry on 03/03/20.	0.50	Powertrain	1
02/13/20	1,114	Charge port door will not stay shut.	Not attended to.	---	Body	4
02/14/20	1,132	Streetside front air bag failed.	Air bag was found to be rubbing on rough edge of dried paint on frame. Replaced failed air bag.	2.00	Suspension	3
02/21/20	1,132	AC unit has two missing bolts and two loose bolts.	Tightened loose bolts and replaced missing bolts.	0.10	A/C	3
02/24/20	2,291	Front sway bar and bushings were damaged.	Replaced front sway bar and bushings.	0.50	Suspension	3
02/25/20	2,331	Bushings installed on previous day only lasted 40 miles.	Bus manufacturer's representative provided replacement bushings which are made of a stiffer rubber material. Streetside bushing had fallen out of the clamp. Bushings on both sides were torn. Replaced D-bushings on both curbside and streetside of front sway bar.	1.25	Suspension	3
02/27/20	2,350	Sway bar bushing on streetside pushed out.	Bushings were replaced with earlier version with softer rubber material. Longer bolts were installed to reduce sway bar noise.	1.00	Suspension	3
03/03/20	2,549	Streetside front sway bar links were broken and the curbside sway bar links were cracked.	Both streetside and curbside sway bar links were replaced.	1.00	Suspension	3

Unscheduled Maintenance  
New Flyer Bus# 1915-P  
(Page 2 of 7)

Date	Test Miles	Issue	Action	Labor Hours	Sub-system	Class
03/03/20 To 07/06/21	2,602 To 18,356	Check system and stop system lights come on, bus loses power to the drive wheels, rolls to a stop and lunges backwards. This happened multiple times during this period.	Manufacturer's representative replaced speed sensor on electric motor on 02/08/21. This did not resolve the issue.  To improve error detection and avoid occurrence of reverse torque events in case of an intermittent encoder/speed sensor fault, the manufacturer's representative re-flashed the inverter and digital input control unit to detect a faulted encoder and place the vehicle into neutral on 07/06/21. The vehicle software was also updated to provide the driver with visual and audible warnings that an encoder fault might have occurred.	2.80	Powertrain	1
			The FTA determined that an additional 1,000 miles were to be completed at the end of the test to verify that the repairs that were done to correct this problem were effective. The additional miles were completed with no reoccurrence.			
03/05/20	2,602	12/24 volt batteries are continually discharging.	Replaced all four batteries with new batteries.	1.00	Electrical	4
03/11/20	2,629	Bus shut down on track.	Manufacturer's representative updated Siemens software for control unit and inverters. Updated parameters to latest version.	0.50	Powertrain	2
03/12/20	2,629	Stabilizer bar is making noise.	Changed washers on stabilizer bar brackets to larger diameter for more clamp force.	0.50	Suspension	4
03/13/20 to 03/19/20	2,726 to 3,452	Sway bar making a popping/cracking noise.	Both sway bar links on the front streetside have cracked in half. New streetside front sway bar links installed, replaced sway bar bushing and tightened bolts.	0.50	Suspension	3

**Unscheduled Maintenance  
New Flyer Bus# 1915-P**  
(Page 3 of 7)

Date	Test Miles	Issue	Action	Labor Hours	Sub-system	Class
07/16/20	3,638	Front curbside upper radius rod bushings failed.	Replaced front upper curbside radius rod.	0.50	Suspension	3
07/16/20	3,732	A/C not working.	Bus taken to ThermoKing for repair. Evacuated A/C system, replaced dryer, silver soldered joint causing failure, checked repair. Recharged A/C system, checked system.	2.00	A/C	4
07/18/20	3,762	A/C not working.	Bus taken to ThermoKing for repair. Rear unit configuration file was not correct. Installed correct configuration file.	1.00	A/C	4
07/20/20	4,024	Steering is shaking.	Rear bushing on upper streetside front radius rod is pushing out. Replaced radius rod with a new one.	1.50	Suspension	3
07/28/20	4,252	A/C not working.	Thermoking repaired pressure line from the streetside compressor to the condenser.	2.00	A/C	4
08/03/20	4,866	A/C not working.	Thermoking repaired streetside pressure line, replaced upper compressor mount and replaced stripped nut at compressor base.	3.00	A/C	4
08/03/20	4,866	Front sway bar is broken.	Replaced front sway bar and installed new bushings.	0.50	Suspension	3
08/11/20	5,316	Lower curbside rear radius rod is worn.	Replaced lower curbside rear radius rod.	1.00	Suspension	3

Unscheduled Maintenance  
New Flyer Bus# 1915-P  
(Page 4 of 7)

Date	Test Miles	Issue	Action	Labor Hours	Sub-system	Class
08/14/20 to 08/18/20	5,923 to 6,328	Red stop light system / Charger did not connect and charge.	Secured cables to the CCS (combined charging system) charge modem, "stop sys" happened on a charge attempt, vehicle connected and charged after removing and reinstalling cables to CCS modem. On 08/18/20, the rear ESS (energy storage system) compartment HV interlock was tripped and a broken wire on interlock circuit was repaired. This addressed the 08/14/20 issue.	1.50	Electrical	3
08/20/20	6,328	Lower radius rod bushings on streetside rear axle failed.	Replaced lower radius rod on streetside rear axle.	1.00	Suspension	3
09/02/20	7,887	Streetside window bracket loose and leaking.	Replaced window retention screws.	0.50	Body	3
09/03/20	7,977	All eight sway bar saddle bolts were loose; four backed out on the streetside and four were somewhat loose on the curbside.	Manufacturer's representative provided eight new bolts and installed them using lock tide on them and torquing them to 160 ft. lbs.	1.00	Suspension	3
			Removed sway bar and brackets, cleaned for welding. Welded crack in front support beam by the rear of the front wheels curbside, streetside and middle. Original mounting brackets for the sway bar had to be cut off and the frame was ground smooth.			
			New mounting brackets and steel plating were welded to crossbeam.			
09/08/20 to 10/28/20	7,977 to 8,027	Cracks found in front support beam by the rear of the front wheels, curbside, streetside and middle. Several cracks formed in the structure just behind the sway bar mount.	Cracks were welded in structure behind front sway bar mount, new supports and plates were added. This work was done by the manufacturer's representatives.	36.00	Frame	3

**Unscheduled Maintenance  
New Flyer Bus# 1915-P  
(Page 5 of 7)**

Date	Test Miles	Issue	Action	Labor Hours	Sub-system	Class
09/08/20 to 10/28/20 (cont.)			The FTA determined that an additional 2,625 miles at GVW and then an additional 350 miles at SLW be completed on the durability track to prove this repair. The additional miles were completed and no further failure to the repaired structure was noticed.			
11/02/20	8,331	Curbside front airbag blown.	Replaced air bag on curbside front	1.50	Suspension	3
11/03/20	8,494	No upper marker/clearance lights.	Technician found the connector behind the clearance lights came loose. The connector was reconnected.	0.25	Electrical	3
11/04/20	8,608	Clearance lights not working.	Relieved a pinched wire at the upper curbside clearance light.	0.10	Electrical	3
11/05/20	8,799	The front sway bar bushing on the streetside is torn.	The front sway bar bushing that was torn was removed and replaced. It was also noticed that the saddle bolt threads were damaged. The threads were repaired using a tap and die and reassembled with blue lock tite.	2.00	Suspension	3
11/11/20	9,036	Front sway bar bushings damaged.	Streetside sway bar bushing was replaced.	0.50	Suspension	3
11/18/20	9,097	Front sway bar bushings were damaged and needed replaced.	The streetside sway bar bushing was replaced on 11/11/20. The curbside bushing was replaced. In addition, backing plates were installed behind the bushings to help keep bushings from being damaged by the frame.	1.00	Suspension	3

Unscheduled Maintenance  
New Flyer Bus# 1915-P  
(Page 6 of 7)

Date	Test Miles	Issue	Action	Labor Hours	Sub-system	Class
11/24/20	9,722	The bus shuts down on track repeatedly.	Movement of inverter door proximity switch on the roof caused intermittent HV interlock signals that resulted in the repeated shutdown. The inverter door proximity switch was adjusted.	0.50	Electrical	3
12/01/20	9,770	The mounting bracket for the air compressor filter (located in the rear curbside compartment under the HV charging box) cracked and needs replaced.	The mounting bracket was replaced. Filter housing and hose were mounted and re-attached.	1.00	Hardware	3
12/01/20	9,772	Bus lost power to drive wheels but did not shut off.	Cycled power. Issue was resolved.	0.05	Electrical	3
01/22/21	11,023	The bus would not charge properly.	Removed and replaced cooling pump for motor inverter. The system was bled and the coolant level was topped off.	1.00	Electrical/ Cooling	3
02/10/21	11,418	Vehicle does not connect to charger.	Coolant pump not receiving or transmitting CAN signal. Replaced 3 sockets on the CAN cable to the pump.	1.00	Electrical/ Cooling	3
02/11/21	11,498	Bus not starting after charge.	Cycled the 24-volt system.	0.05	Electrical	3
02/11/21	11,529	Bus shut down on track. Towed to shop.	Error codes showed loss of coolant pressure. Repaired two pins at the inverter coolant pump.	0.50	Coolant (Battery)	2
02/15/21	11,763	Front sway bar bushings were worn.	Front bushings were replaced.	1.00	Suspension	3
02/17/21	11,937	Front streetside sway bar is broken.	Replaced front streetside sway bar	1.00	Suspension	3
03/01/21	12,261	Streetside headlight does not work on low beam.	Streetside headlight was replaced.	1.00	Lighting	3

Unscheduled Maintenance  
New Flyer Bus# 1915-P  
(Page 7 of 7)

Date	Test Miles	Issue	Action	Labor Hours	Sub-system	Class
03/01/21	12,261	Two curbside windows and two streetside windows are loose.	The windows were missing screws. Replaced screws in each of the four windows to secure them in place.	0.25	Body	3
03/02/21	12,262	The curbside front airbag was starting to split at the top of the spring.	Replaced the damaged airbag.	1.00	Suspension	3
03/12/21	12,918	Vehicle does not connect to charger.	Installed program in vehicle that addressed a timing problem during connections.	0.10	Electrical / Charging	3
03/17/21	13,267	Isolators were worn out on the electric hydraulic power steering pump.	Replaced isolators on the electric hydraulic power steering pump. (This required removal of windshield washer tank for access.)	1.00	Suspension / Steering	3
03/17/21	13,267	Windows above rear wheels were coming loose.	Tightened screws in windows above rear axle as well as replaced a few that were missing.	0.10	Body	3
03/18/21	13,394	Windshield leaking on driver's side.	Sealer applied around rubber gasket of windshield as per manufacturer's representative.	0.50	Body/Glass	3
03/30/21	14,384	Front sway bar and bushings are worn.	New sway bar and bushings were installed. Saddle bolts were torqued to 175 ft. lbs per manufacturer.	0.50	Suspension	3
03/30/21	14,384	Curbside front airbag on the rear axle was leaking. Streetside front airbag on the rear axle had weathered cracks in it and it was gouged.	Both airbags were replaced.	2.50	Suspension	3
04/05/21	15,075	K-member in front of rear lower torque rods is cracked.	Removed and replaced K-member with new. Reused all hardware, replaced mounting shims as needed and torqued all mounting hardware according to manufacturer specifications.	5.00	Frame	3

New Flyer Bus# 1915-P – Issues Related to Siemens Charger		
Date	Issue	Action
03/16/20	Bus will not charge.	No action taken.
08/17/20	Bus will not charge.	No action taken.
08/31/20	Bus will not connect to charger.	No action taken.
11/23/20	Bus will not connect to charger.	No action taken.
12/08/20	State of charge showing 0% on dash, charger shows 90%.	No action taken.
01/15/21	Bus would not connect to charger – Charger kept timing out.	No action taken.
01/18/21	Bus would not connect to charger – Charger kept timing out.	No action taken.
01/19/21	Bus would not connect to charger – Charger kept timing out. Connected on the fifth try.	No action taken.
01/27/21 to 02/01/21	Cannot charge bus.	Manufacturer's representative had to plug laptop in to get it to charge.
02/11/21	Bus would not connect to charger.	Had to switch to "Day Run" to get bus to connect and charge. After charging is complete, must cycle 24 V system to start bus.
03/04/21	Keyed bus to on, let it boot up. State of charge at 58%, started bus and it went up to 90%. After walk around pre-trip, state of charge was 88%. Drove to the durability track, state of charge dropped to 85%, ran six miles, dropped to 79% continued to run, dropped to 60% on the next lap. After that, it started to use 1% state of charge per mile which is normal.	No action taken.
03/08/21 to 03/10/21	Needs to be in "Day Run" to connect to charger.	Software update to charger. Now connects to charger with switch in off position.
03/15/21 to 03/17/21	Bus would not connect to charger.	New software update to charger.

## UNSCHEDULED MAINTENANCE

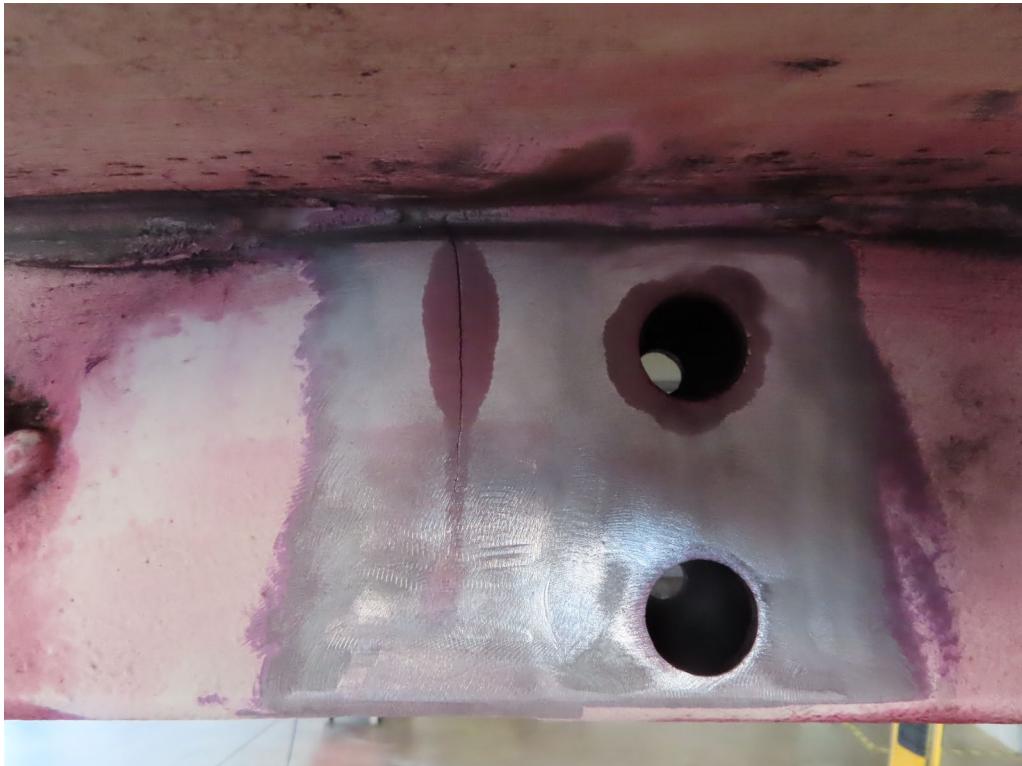


**BROKEN FRONT SWAY BAR  
(2,291 TEST MILES)**

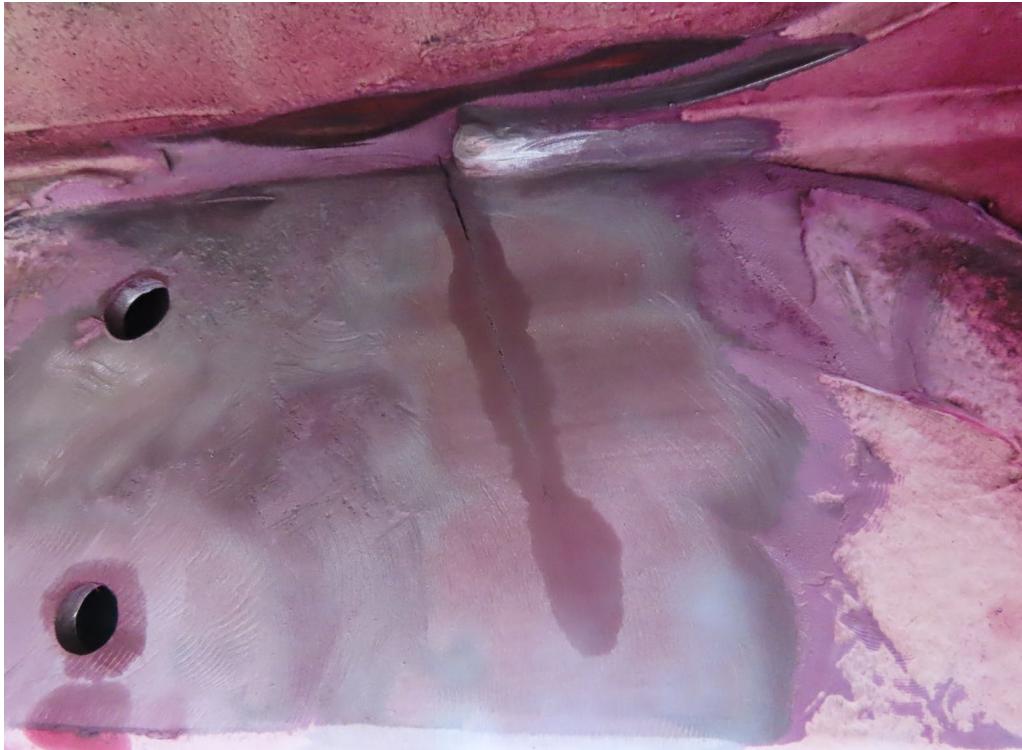


**BROKEN FRONT SWAY BAR LINK  
(2,549 TEST MILES)**

## **UNSCHEDULED MAINTENANCE CONT.**



**CRACK FOUND IN FRONT SWAY BAR MOUNT LOCATION  
(8,027 TEST MILES)**



**CRACK FOUND IN FRONT SWAY BAR MOUNT LOCATION  
(8,027 TEST MILES)**

## UNSCHEDULED MAINTENANCE CONT.



**FRONT SWAY BAR MOUNT LOCATION REPAIRED  
(8,027 TEST MILES)**



**BLOWN CURBSIDE FRONT AIRBAG  
(8,331 TEST MILES)**

## UNSCHEDULED MAINTENANCE CONT.



**REPLACED COOLING PUMP FOR MOTOR INVERTER  
(11,023 TEST MILES)**



**FRONT SWAY BAR IS BROKEN ON THE STREETSIDE  
(11,937 TEST MILES)**

## UNSCHEDULED MAINTENANCE CONT.



**CURBSIDE FRONT AIRBAG IS STARTING TO SPLIT  
(12,262 TEST MILES)**



**WORN ISOLATORS FROM ELECTRIC HYDRAULIC STEERING PUMP  
(13,267 TEST MILES)**

## **6. ENERGY ECONOMY AND RANGE TEST – AN ENERGY CONSUMPTION AND RANGE TEST FOR BATTERY ELECTRIC BUSES USING APPROPRIATE OPERATING CYCLES**

### **6-I. TEST OBJECTIVE**

The objective of this test is to provide accurate comparable energy consumption data on battery electric transit buses produced by different manufacturers. This energy 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 energy economy test, as designated here, is a measurement of the energy consumed by a vehicle traveling a specified test operating profile, under specified operating conditions that are typical of transit bus operation. The results of this test will not represent actual energy usage but will provide data that can be used by FTA Grantees to compare buses tested using this procedure.

### **6-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 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 HD-UDDS Cycle (Figure 3). This test is conducted at simulated seated load weight.

This test is conducted generally as per the methods described in the SAE standard J 1634-2017. The light-duty test cycles specified in this standard are replaced by transit bus test cycles mentioned above.

The Multi-Cycle test (MCT) procedure is adopted for this bus. The end of test is determined when the bus cannot keep up with the speed trace of the test cycle, as recommended by the bus manufacturer. During the test the net DC energy (kWh) drawn from the battery pack is recorded. The battery system is recharged to full SOC at the end of the test, following procedures specified in SAE J 1634-2017. During the recharge, the DC energy (into the battery pack) and the AC energy (into the charger) are recorded. From these data, the average AC energy consumption (kWh/mi), the range (miles) and the charger efficiency (%) are calculated and reported.

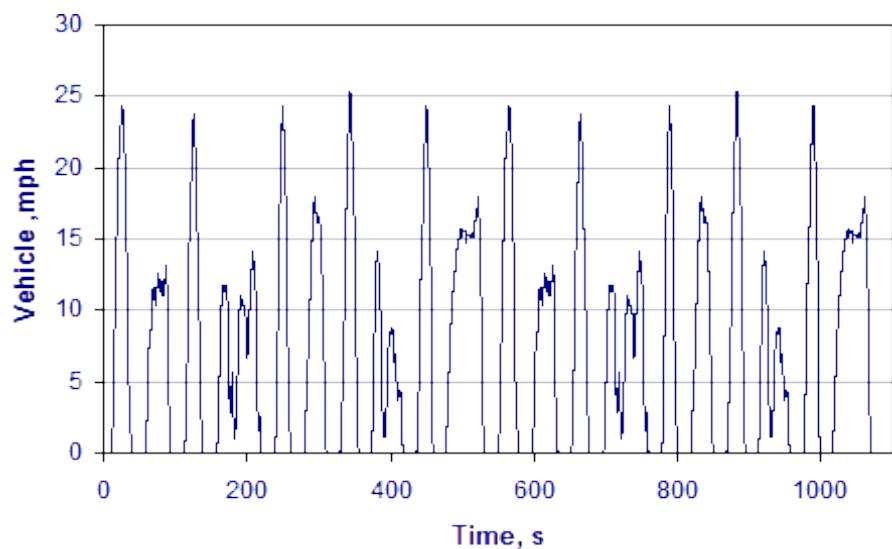


Figure 1. Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4 mph, average speed 6.8 mph)

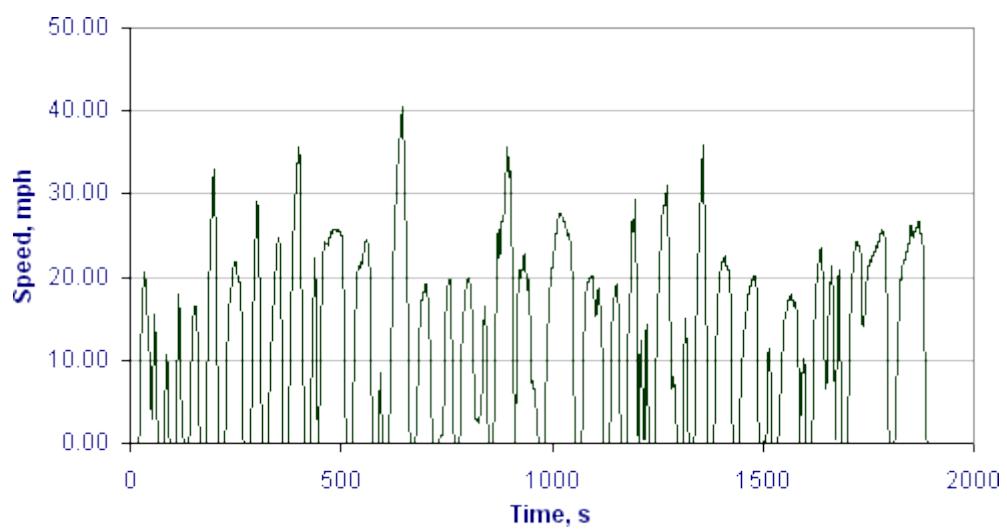


Figure 2. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41 mph, Average Speed 12 mph).

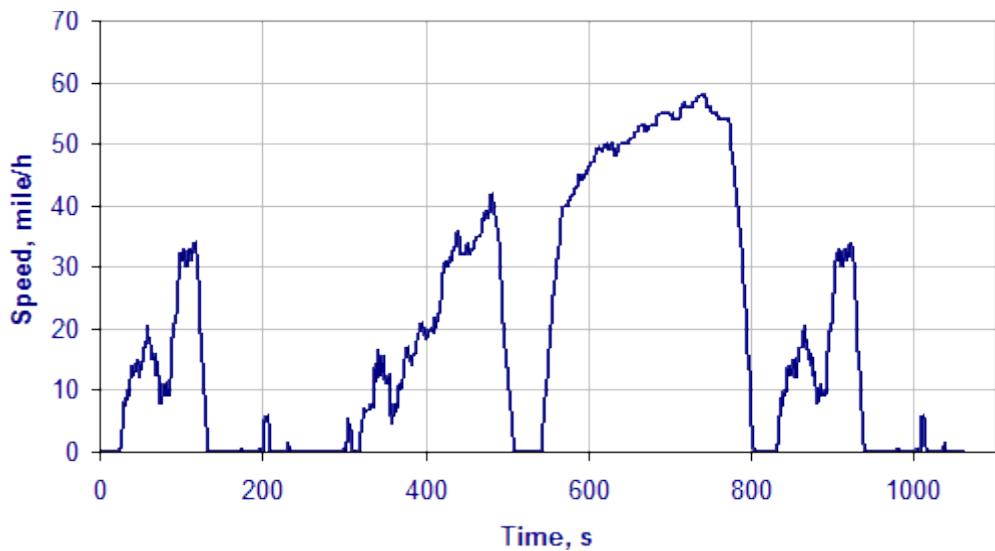


Figure 3. HD-UDDS Cycle (duration 1060 seconds, Maximum Speed 58 mph, Average Speed 18.86 mph).

### 6-III. DISCUSSION

The driving cycle consists of three simulated transit driving cycles: Manhattan, Orange County Bus Cycle and the HD-UDDS, as described in 6-II.

An extensive pretest maintenance check is conducted including the replacement of all lubrication fluids, if applicable. The details of the pretest maintenance are given in the first three Pretest Maintenance Forms. The fourth sheet shows the Pretest Inspection Form. Finally, the summary sheet provides the average energy consumption and range of bus for the three test cycles. The test was conducted at a simulated seated load weight of 40,500 lbs. The average AC energy consumption for the Manhattan, OCBC and the HD-UDDS were 2,767 Wh/mile, 2,176 Wh/mile and 1,980 Wh/mile respectively.

The range for the three driving cycles were 121 miles, 154 miles and 170 miles respectively. After the test was completed, it was brought to the test center's attention, by the manufacturer's representative, that one of the six battery strings was offline during the test. There was no indication on the driver's instrument panel that one of the strings was offline. The manufacturer was offered to retest, but the offer was declined.

This bus was tested using the Manhattan, Orange County and UDDS driving cycles. The energy economy and range results for buses tested using these cycles are not directly comparable to buses tested under the earlier protocol that uses the CBD, Arterial and Commuter driving cycles.

Since the Siemens charger provided by the manufacturer was not portable, a portable Charge Point charger was used for the energy economy tests.

# ENERGY ECONOMY PRE-TEST MAINTENANCE FORM

Page 1 of 3

Bus Number: 1915-P	Date: 11/25/2020	SLW (lb.): 40,500
Personnel: S.R., T.G. & E.L.		

ENERGY SYSTEM		OK
Install energy measurement system		✓
Remarks: None noted.		
BRAKES/TIRES		OK
Inspect hoses		✓
Inspect brakes		✓
Check tire inflation pressures (mfg. specs.)		✓
Check tire wear (less than 50%)		✓
Remarks: None noted.		
BATTERY COOLING SYSTEM		OK
Check hoses and connections		✓
Check system for coolant leaks		✓
Remarks: None noted.		

# ENERGY ECONOMY PRE-TEST MAINTENANCE FORM

Page 2 of 3

Bus Number: 1915-P	Date: 11/25/2020
Personnel: S.R., T.G. & E.L.	
<b>ELECTRICAL SYSTEM</b>	
Check battery	✓
Inspect wiring	✓
Inspect terminals	✓
Check lighting	✓
Remarks: None noted.	
<b>DRIVE SYSTEM</b>	
Drain transmission fluid	N/A
Replace filter/gasket	N/A
Check hoses and connections	N/A
Replace transmission fluid	N/A
Check for fluid leaks	N/A
Remarks: None noted.	
<b>LUBRICATION</b>	
Lube all chassis grease fittings	✓
Lube universal joints	✓
Replace differential lube including axles	N/A
Remarks: None noted.	

## ENERGY ECONOMY PRE-TEST MAINTENANCE FORM

Page 3 of 3

Bus Number: 1915-P	Date: 11/25/2020										
Personnel: S.R., T.G. & E.L.											
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">OTHER ITEMS</th> <th>OK</th> </tr> </thead> <tbody> <tr> <td>Replace air filter</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Inspect air compressor and air system</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Inspect vacuum system, if applicable</td> <td style="text-align: center;">N/A</td> </tr> <tr> <td>Check and adjust all drive belts</td> <td style="text-align: center;">N/A</td> </tr> </tbody> </table>		OTHER ITEMS	OK	Replace air filter	✓	Inspect air compressor and air system	✓	Inspect vacuum system, if applicable	N/A	Check and adjust all drive belts	N/A
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	OK										
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TEST DRIVE	OK										
Check brake operation	✓										
Check transmission operation	✓										
Remarks: None noted											

# ENERGY ECONOMY PRE-TEST INSPECTION FORM

Page 1 of 1

Bus Number: 1915-P	Date: 12/15/2020
Personnel: T.G., E.L. & F.T.	
PRE WARM-UP	
Energy Economy Pre-Test Maintenance Form is complete	E.L.
Cold tire pressure (psi): Front <u>130</u> Middle <u>N/A</u> Rear <u>130</u>	E.L.
Energy economy instrumentation installed and working properly.	E.L.
Bus is loaded to SLW during coast down	E.L.
WARM-UP	
Interior and exterior lights on, evaporator fan on	F.T.
Air conditioner off	F.T.
Defroster off	F.T.
Windows and doors closed	F.T.
Do not drive with left foot on brake	F.T.

## **ENERGY ECONOMY DATA FORM (Battery Electric Buses)**

Page 1 of 1

Bus Number: 1915-P	Manufacturer: New Flyer	Date: 12/15/2020
Fuel Type: Electric	Personnel: F.T. & S.I.	
Temperature (°F): 67.2	Humidity (%): 13.0	Barometric Pressure (inHg): 29.0
SLW (lb.): 40,500	Charger: Charge Point	

	<b>Manhattan</b>	<b>Orange County</b>	<b>UDDS</b>
AC Energy (Wh/mile)	2767	2176	1980
Range (miles)	121	154	170
Charger Efficiency (%)		94	

<b>Comments:</b> After the test was completed, it was brought to the test center's attention by the manufacturer's representative that one of the six battery strings was offline during the test. There was no indication on the driver's instrument panel that one of the strings was offline. The manufacturer was offered to retest, but the offer was declined.
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## 6.0 ENERGY ECONOMY



**BUS TESTED ON CHASSIS DYNAMOMETER FOR PERFORMANCE AND ENERGY ECONOMY**



**CHARGE POINT CHARGER USED FOR PERFORMANCE AND ENERGY ECONOMY TESTS**