

FEDERAL TRANSIT BUS TEST

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

**Manufacturer: Starcraft Bus, Startrans Bus
Divisions of Forest River
Model: F-550 Allstar XL / F-550 Senator II HD**

**Tested in Service-Life Category
7 Year / 200,000 Miles**

February 2019

Report Number: LTI-BT-R1810

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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

Manufacturer: Starcraft Bus, Startrans Bus
Divisions of Forest River

Manufacturer's address: 2367 Century Drive
Goshen, IN 46528

Model: F-550 Allstar XL / F-550 Senator II HD

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Quality Authorization

Director, Bus Research
and Testing Center

Title

2/19/19

Date

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EXECUTIVE SUMMARY

TEST HIGHLIGHTS

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.

Manufacturer	Starcraft Bus, Startrans Bus, Divisions of Forest River
Model	F-550 Allstar XL / F-550 Senator II HD
Chassis Make/Model	Ford Motor Co. / F-550 XL
Chassis Modified	Yes
Length	32 feet, 11 ½ inches
Fuel	CNG
Service Life	7 years / 200,000 miles
Number of Seats (including driver)	31 (6 seats fold away for 2 wheelchairs)
Manufacturer-Designated Standing Passenger Capacity	0
Gross Vehicle Weight used for testing	18,850
Gross Vehicle Weight Rating	19,500
Mileage at Delivery	110
Test Start Date	10/09/18
Test Completion Date	12/12/18

The measured curb weight was 4,610 lb. for the front axle and 9,210 lb. for the rear axle. These combined weights provided a total measured curb weight of 13,820 lb. There are 31 seats including the driver (or 25 seats and 2 wheelchair positions) and free floor space for 16 standing passengers bringing the potential total passenger capacity to 47. However, a placard shows that there are to be no standing passengers. Therefore, the gross load represents seated passengers only, for a total of 25 passengers and 2 wheelchairs. Gross load is calculated as $(150 \text{ lb.} \times 25) + (600 \text{ lb.} \times 2) = 4,950 \text{ lb.}$ At full declared capacity, the measured gross vehicle weight was 18,850 lb. There is a potential to overload this bus with the available floor space for standing passengers.

The FTA determination letter outlines the GAWR for the front axle as 6,000 lb. However, the VIN plate on the test bus specifies the GAWR for the front axle as 6,500 lb. It is noted that at the passenger capacities declared by the manufacturer, neither of the two above axle ratings were exceeded.

BUS TESTING BACKGROUND

On August 1, 2016, FTA announced a final rule for bus testing for improving the process of ensuring the safety and reliability of new transit buses. The rule satisfies requirements in MAP-21 to establish minimum performance standards, a standardized scoring system, and a pass-fail threshold based on the score.

FTA's Bus Testing Program (often referred to as "Altoona Testing" due to the location of the main testing center) tests new transit bus models for:

- Maintainability
- Reliability
- Safety
- Performance (including Braking Performance)
- Structural Integrity (including Structural Durability)
- Fuel Economy (Energy Efficiency and Range, for electric buses)
- Noise
- Emissions

Bus models that fail to meet one or more minimum performance standards will "fail" their test and thus be ineligible for purchase with FTA funds until the failures are resolved and validated through further testing. FTA will use this authority to make sure defects are corrected before a bus model can be acquired with FTA funding.

In each application to FTA for the purchase or lease of any new bus model, or any bus model with a major change in configuration or components to be acquired or leased with funds obligated by the FTA, the recipient shall certify that it has received the appropriate full Bus Testing Report and any applicable partial testing report(s) before final acceptance of the first vehicle. In dealing with a bus manufacturer or dealer, the recipient shall be responsible for determining whether a vehicle to be acquired requires full testing or partial testing or has already satisfied the requirements of this part. A bus manufacturer or recipient may request guidance from FTA in making these determinations.

The purpose of the testing is intended set a "Pass/Fail" standard and grade the performance of the buses in order to provide performance information to the transit authorities that can be used in their purchase or lease decisions. The intent of this report is to provide the grantee a relative measure of the performance of a particular model of transit bus against a standard of performance. The passing of this test should ensure a vehicle has a high probability of meeting its service life in the category it was tested.

The data included in this test report and other applicable reports should be reviewed to choose the most suitable bus for a grantee's operation. A higher scoring bus is not necessarily the best bus for a given application. For example, a bus with a powerful engine may score well because of its performance and gradeability, but another bus with a smaller and more fuel-efficient engine could be a better choice for applications in mostly flat areas. It is the responsibility of the grantee to ensure the proper test report or applicable partial report is in their possession and has been thoroughly reviewed.

The score sheet for the subject vehicle of this test report is provided below. **This bus passed the Altoona test, with an aggregate score of 89.6.**

Starcraft Bus# 1810									
Test category	Standard	Base Pts.	Bonus Pts.	Range	Test Data	Score	FAIL		
1. Maintainability	Unscheduled maint.	2	14	0	125	15.7			
2. Reliability	# Class 2 failures	2	6	0	2	8.0			
	Hazards	10	0	P	F	10.0			
	Stability	2.5	0	P	F	2.5			
3. Safety	< 158 feet at 45mph	0.5	2	80	158	1.8			
	Braking	2.5	0	P	F	2.5			
	Acceleration 0-30 mph	2.5	0	P	F	2.5			
	Gradeability 2.5%	2.5	0	P	F	2.5			
4. Performance	Gradeability 10%	1.5	0	P	F	1.5			
	Distortion	2	0	P	F	2.0			
	Static Towing	1	0	P	F	1.0			
	Dynamic Towing	1	0	P	F	1.0			
5. Structural Integrity	Jacking	1	0	P	F	1.0			
	Hoisting	1	0	P	F	1.0			
	Durability-Structural	13	0	P	F	13.0			
	Durability-Powertrain	12	0	P	F	12.0			
	Liquid fuels	1-13mpg		1	13	0.0			
6. Fuel Economy	CNG	10-50 scf/mi	1	6	50	4.4			
	Hydrogen	15-98 cf/mi		15	98	0.0			
	Electric	1-3 kWh/mi		1	3	0.0			
7. Noise	Int. Noise (0-35 mph)	0.5	3	30	80	0.8			
	Ext. Noise (0-35 mph)	0.5	3	50	83	1.0			
	CO ₂	0-4000 g/mi	4	0	4000	3.5			
	CO	0-20 g/mi	0.4	0	20	0.4			
8. Emissions	Total hydrocarbon	0-3 g/mi	0.4	0	3	0.4			
	NMHC	0-3 g/mi	0.4	0	3	0.4			
	Nitrogen oxides	0-3 g/mi	0.4	0	2	0.3			
	Particulates	0-0.1 g/m	0.4	0	0.1	0.4			
Total		60	40			89.6			

Note: The use of the scoring system is not mandatory for procurement. It is only necessary that the bus being procured has received a passing score.

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
WC	- water capacity
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 Starcraft Bus, Startrans Bus, Divisions of Forest River, model F-550 Allstar XL / F-550 Senator II HD. The bus has a front passenger door located behind the front axle, and a passenger door with a wheelchair lift located behind the rear axle. Power is provided by a CNG-fueled, Ford Motor Company 6.8L engine coupled to a Ford Motor Company Torqshift 6 transmission.

The measured curb weight was 4,610 lb. for the front axle and 9,210 lb. for the rear axle. These combined weights provided a total measured curb weight of 13,820 lb. There are 31 seats including the driver (or 25 seats and 2 wheelchair positions) and free floor space for 16 standing passengers bringing the potential total passenger capacity to 47. However, a placard shows that there are to be no standing passengers. Therefore, the gross load represents seated passengers only, for a total of 25 passengers and 2 wheelchairs. Gross load is calculated as $(150 \text{ lb.} \times 25) + (600 \text{ lb.} \times 2) = 4,950 \text{ lb.}$ At full declared capacity, the measured gross vehicle weight was 18,850 lb. There is a potential to overload this bus with the available floor space for standing passengers.

The FTA determination letter outlines the GAWR for the front axle as 6,000 lb. However, the VIN plate on the test bus specifies the GAWR for the front axle as 6,500 lb. It is noted that at the passenger capacities declared by the manufacturer, neither of the two above axle ratings were exceeded.

VEHICLE DATA FORM

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Bus Number: 1810	Date of Check-In: 10-09-19
Bus Manufacturer: Starcraft Bus, Startrans Bus, Divisions of Forest River	Vehicle Identification Number (VIN): 1FDGF5GVXJEB75751
Model Number: Allstar XL / Senator II HD	Chassis Mfr./Mod.#: Ford Motor Co. / F550 XL
Personnel: S.R., E.D., E.L. & P.D.	Starting Odometer Reading: 110

WEIGHT:

Individual Wheel Reactions:

Weights (lb.)	Front Axle		Middle Axle		Rear Axle	
	Curb	Street	Curb	Street	Curb	Street
CW	2,570	2,040	N/A	N/A	4,620	4,590
SLW	2,830	2,240	N/A	N/A	6,780	7,000
GVW	2,830	2,240	N/A	N/A	6,780	7,000

Total Weight Details:

Weight (lb.)	CW	SLW	GVW	GAWR
Front Axle	4,610	5,070	5,070	6,500
Middle Axle	N/A	N/A	N/A	N/A
Rear Axle	9,210	13,780	13,780	14,706
Total	13,820	18,850	18,850	Manufacturer Specified GVWR: 19,500

Dimensions:

Length (ft/in)	32 / 11 ½
Width (in)	97
Height (in)	130 ¼
Front Overhang (in)	37 ¾
Rear Overhang (in)	119
Wheel Base (in)	238 ¾
Wheel Track (in)	Front: 75
	Middle: N/A
	Rear: 74.3

VEHICLE DATA FORM

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Bus Number: 1810	Date: 10-09-18
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CLEARANCES:

Lowest Point Outside Front Axle	Location: Spoiler	Clearance(in): 14.1
Lowest Point Outside Rear Axle	Location: Exhaust Clamp	Clearance(in): 15.0
Lowest Point between Axles	Location: Body at Stepwell	Clearance(in): 8.8
Ground Clearance at the center (in)	10.7	
Front Approach Angle (deg)*	20.5	
Rear Approach Angle (deg)*	8.5	
Ramp Clearance Angle (deg)	5.1	
Aisle Width (in)	18.6	
Inside Standing Height at Center Aisle (in)	78.3	

*measurements used to calculate approach and departure angles are taken from the center-line of the axles.

BODY DETAILS:

Body Structural Type	Integral		
Frame Material	Steel		
Body Material	Aluminum		
Floor Material	Plywood		
Roof Material	Fiberglass		
Windows Type	<input checked="" type="checkbox"/> Fixed	<input type="checkbox"/> Movable	
Window Mfg./Model No.	Lippert Components / 36 x 36 DOT 07-008-005 Lippert Components / 36 x 36 Egress 07006-038		
Number of Doors	<u>2</u> Front	<u>1</u> Rear	
Mfr. / Model No.	Front Streetside: Ford / OEM Front Curbside: A&M Systems / D250174 (L) & D250172(R) Rear Curbside: Challenger Door / MTCRWH30		
Dimension of Each Door (in)	Front Streetside: 45.5 x 31.8	Front Curbside: 85.8 x 35.8	Rear Curbside: 85.8 x 35.8
Passenger Seat Type	<input type="checkbox"/> Cantilever	<input checked="" type="checkbox"/> Pedestal	<input type="checkbox"/> Other (explain)
Driver Seat Type	<input type="checkbox"/> Air	<input checked="" type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	Ford/OEM to chassis		
Number of Seats (including Driver)	31 (6 seats fold away for 2 wheelchairs)		

VEHICLE DATA FORM

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Bus Number: 1810	Date: 10-09-18
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BODY DETAILS (Contd.)

Free Floor Space (ft ²)	25.3
Height of Each Step at Normal Position (in)	Front 1. <u>11.3</u> 2. <u>10.1</u> 3. <u>10.1</u> 4. <u>5.3</u>
	Middle 1. <u>N/A</u> 2. <u>N/A</u> 3. <u>N/A</u> 4. <u>N/A</u>
	Rear 1. <u>N/A</u> 2. <u>N/A</u> 3. <u>N/A</u> 4. <u>N/A</u>
Step Elevation Change - Kneeling (in)	N/A

ENGINE

Type	<input type="checkbox"/> C.I.	<input type="checkbox"/> Alternate Fuel	
	<input checked="" type="checkbox"/> S.I.	<input type="checkbox"/> Other (explain)	
Mfr. / Model No.	Ford Motor Co. / 6.8 L		
Location	<input type="checkbox"/> Front	<input type="checkbox"/> Rear	<input type="checkbox"/> Other (explain)
Fuel Type	<input type="checkbox"/> Gasoline	<input checked="" type="checkbox"/> CNG	<input type="checkbox"/> Methanol
	<input type="checkbox"/> Diesel	<input type="checkbox"/> LNG	<input type="checkbox"/> Other (explain)
Alternator (Generator) Mfr./Model No.	Ford Motor Co. / HC3T-10300-DB		
Maximum Rated Output (Volts / Amps)	12/240		
Air Compressor Mfr. / Model No.	N/A		
Maximum Capacity (ft ³ / min)	N/A		
Starter Type	<input checked="" type="checkbox"/> Electrical	<input type="checkbox"/> Pneumatic	<input type="checkbox"/> Other (explain)
Starter Mfr. / Model No.	Ford / DL3T1100AA		

VEHICLE DATA FORM

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Bus Number: 1810	Date: 10-09-18
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TRANSMISSION

Transmission Type	<input type="checkbox"/> Manual	<input checked="" type="checkbox"/> Automatic	<input type="checkbox"/> Load Sensing Adaptive
Mfr. / Model No.	Ford Motor Company / Torqshift 6		
Control Type	<input checked="" type="checkbox"/> Mechanical	<input type="checkbox"/> Electrical	<input type="checkbox"/> Other
Integral Retarder Mfr. / Model No.	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> No	

SUSPENSION

Number of Axles	2		
Front Axle Type	<input type="checkbox"/> Independent	<input checked="" type="checkbox"/> Beam Axle	
Mfr. / Model No.	Ford / OEM to chassis		
Axle Ratio (if driven)	N/A		
Suspension Type	<input type="checkbox"/> Air	<input checked="" type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Ford Motor Co./ HC3C-18045-HE		
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.	Dana / Ford OEM to chassis		
Axle Ratio (if driven)	4.88		
Suspension Type	<input type="checkbox"/> Air	<input checked="" type="checkbox"/> Spring	<input type="checkbox"/> Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Ford Motor Co. / HC3C-18080-DJD		

VEHICLE DATA FORM

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Bus Number: 1810	Date: 10-09-18
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WHEELS & TIRES

Front	Wheel Mfr./ Model No.	Ford / 19.5 x 6.00RW
	Tire Mfr./ Model No.	Continental HST 225/70R19.5
Rear	Wheel Mfr./ Model No.	Ford / 19.5 x 6.00RW
	Tire Mfr./ Model No.	Continental HST 225/70R19.5

BRAKES

Front Axle Brakes Type	<input type="checkbox"/> Cam	<input checked="" type="checkbox"/> Disc	<input type="checkbox"/> Other (explain)
Mfr. / Model No.	Ford OEM to Chassis / HC3Z2001B		
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.	Ford OEM to Chassis / HC3Z22000		

HVAC

Heating System Type	<input type="checkbox"/> Air	<input checked="" type="checkbox"/> Water	<input type="checkbox"/> Other
Capacity (Btu/hr)	65,000		
Mfr. / Model No.	Pro-Air / 465LP		
Air Conditioner	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No	
Location	Rooftop TransAIR TA733 Super		
Capacity (Btu/hr)	68,000		
A/C Compressor Mfr. / Model No.	#1 – Que / QP21-1657 #2 – Ford Motor Co. / OEM		

STEERING

Steering Gear Box Type	Hydraulic Gear		
Mfr. / Model No.	Ford OEM to Chassis / JC3Z3504A		
Steering Wheel Diameter	16		
Number of turns (lock to lock)	4 ½		
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: 1810	Date: 10-09-18
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OTHERS

Wheel Chair Ramps	Location: N/A	Type: N/A
Wheel Chair Lifts	Location: Rear Curbside	Type: Electric Fold out
Mfr. / Model No.	Braun / NL919IB HB-2	
Emergency Exit	Location: Window Door	Number: 5 3
CNG Cylinder Mfr. / Model No.	Luxfer / 2085D-C15	

CAPACITIES

Fuel Tank Capacity (WC)	200 liters
Fuel Tank Pressure	3600 PSI
Engine Crankcase Capacity (gallons)	1.75
Transmission Capacity (gallons)	4.35
Differential Capacity (quarts)	Not specified (Fill 6-14 mm below fill hole)
Cooling System Capacity (gallons)	6.6
Power Steering Fluid Capacity (quarts)	Not specified (Fill reserve as needed)

Page 7 of 7

Bus Number: 1810	Date: 10-12-18
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List all spare parts, tools and manuals delivered with the bus.

[illegible]

COMPONENT/SUBSYSTEM INSPECTION FORM

Page 1 of 1

Bus Number: 1810	Date: 10-09-18
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Subsystem	Checked	Initials	Comments
Air Conditioning Heating and Ventilation	✓	E.D.	None noted
Body and Sheet Metal	✓	E.D.	None noted
Frame	✓	E.D.	None noted
Steering	✓	E.D.	None noted
Suspension	✓	E.D.	None noted
Interior/Seating	✓	S.R.	None noted
Axles	✓	E.D.	None noted
Brakes	✓	E.D.	None noted
Tires/Wheels	✓	E.D.	None noted
Exhaust	✓	E.D.	None noted
Fuel System	✓	E.D.	CNG
Power Plant	✓	E.D.	None noted
Accessories	✓	E.D.	None noted
ADA Accessible Lift System	✓	S.R.	None noted
Interior Fasteners	✓	S.R.	None noted
Batteries	✓	S.R.	None noted

CHECK - IN



STARCRAFT BUS, STARTRANS BUS, DIVISIONS OF FOREST RIVER MODEL F-550 ALLSTAR XL / F-550 SENATOR II



CHECK - IN CONT.



OPERATOR'S AREA

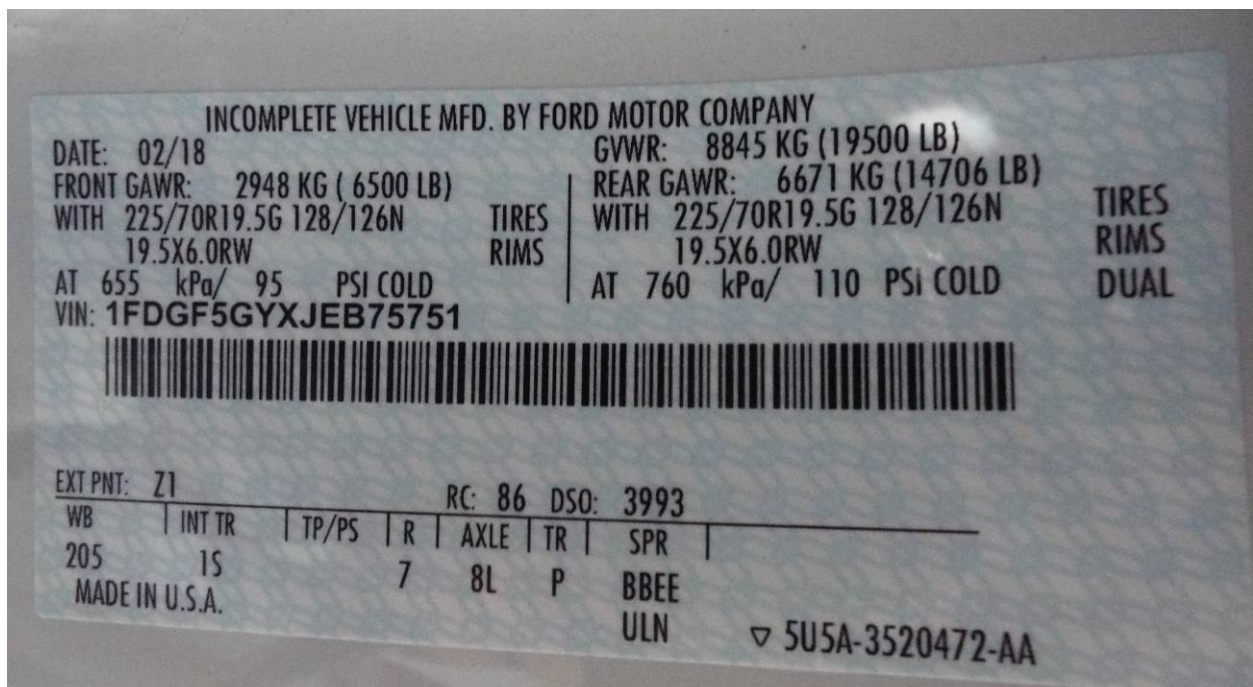


INTERIOR FROM FRONT

CHECK - IN CONT.



INTERIOR FROM REAR



VIN TAG

CHECK - IN CONT.



PLACARD SHOWING NO STANDEES



ENGINE COMPARTMENT

1. MAINTAINABILITY

1.1 ACCESSIBILITY OF COMPONENTS AND SUBSYSTEMS

1.1-I. TEST OBJECTIVE

The objective of this test is to check the accessibility of components and subsystems.

1.1-II. TEST DESCRIPTION

Accessibility of components and subsystems was checked, and where accessibility was restricted the subsystem was noted along with the reason for the restriction.

1.1-III. DISCUSSION

Accessibility, in general, was adequate. Components covered in Section 1.3 (repair and/or replacement of selected subsystems), along with all other components encountered during testing, were found to be readily accessible and no restrictions were noted.

ACCESSIBILITY DATA FORM

Page 1 of 2

Bus Number: 1810	Date: 12-12-18
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Component	Checked	Comments
ENGINE :		
Oil Dipstick	✓	None noted.
Oil Filler Hole	✓	None noted.
Oil Drain Plug	✓	None noted.
Oil Filter	✓	None noted.
Fuel Filter	✓	None noted.
Air Filter	✓	None noted.
Belts	✓	None noted.
Coolant Level	✓	None noted.
Coolant Filler Hole	✓	None noted.
Coolant Drain	✓	None noted.
Spark / Glow Plugs	✓	None noted.
Alternator	✓	None noted.
Diagnostic Interface Connector	✓	None noted.
TRANSMISSION :		
Fluid Dip-Stick	✓	None noted.
Filler Hole	✓	None noted.
Drain Plug	✓	No drain plug.
SUSPENSION :		
Bushings	✓	None noted.
Shock Absorbers	✓	None noted.
Air Springs	N/A	None noted.
Leveling Valves	N/A	None noted.
Grease Fittings	✓	None noted.

ACCESSIBILITY DATA FORM

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Bus Number: 1810	Date: 12-12-18
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Component	Checked	Comments
HVAC :		
A/C Compressor	✓	Two A/C compressors.
Filters	✓	None noted.
Fans	✓	None noted.
ELECTRICAL SYSTEM :		
Fuses	✓	None noted.
Batteries	✓	One under hood, one in side compartment.
Voltage regulator	✓	Internal.
Voltage Converters	✓	None noted.
Lighting	✓	None noted.
MISCELLANEOUS :		
Brakes	✓	None noted.
ADA Accessible Lifts/Ramps	✓	None noted.
Instruments	✓	None noted.
Axles	✓	None noted.
Exhaust	✓	None noted.
Fuel System	✓	None noted.
OTHERS :		None noted.

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
 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
5. Major inspection
6. Tune-up

C. Periodic Repairs

1. Brake reline*
2. 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.

(Page 1 of 1)
SCHEDULED MAINTENANCE
 Starcraft Bus, Startrans Bus, a Division of Forest River Bus# 1810

DATE	TEST MILES	SERVICE	ACTIVITY	DOWN TIME	LABOR HOURS
10-18-18	1,209	P.M./Inspection	Steering linkage, tie rods, ball joints all lubed; universals checked; all fluids checked. Inspected frame, body and suspension.	4.00	4.00
10-25-18	2,501	P.M./Inspection	Steering linkage, tie rods, ball joints all lubed; universals checked; all fluids checked. Inspected frame, body and suspension.	4.00	4.00
10-31-18	3,325	P.M./Inspection	Steering linkage, tie rods, ball joints all lubed; universals checked; all fluids checked. Inspected frame, body and suspension.	4.00	4.00
11-05-18	4,140	P.M./Inspection	Steering linkage, tie rods, ball joints all lubed; universals checked; all fluids checked. Inspected frame, body and suspension.	4.00	4.00
11-15-18	5,180	P.M./Inspection Fuel Economy	Steering linkage, tie rods, universals/u-joints all lubed; all fluids checked. Inspected frame, body and suspension. Oil changed. Oil, fuel, and air filters changed.	8.00	8.00
11-26-18	6,104	P.M./Inspection	Steering linkage, tie rods, ball joints all lubed; universals checked; all fluids checked. Inspected frame, body and suspension.	4.00	4.00

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS

1.3-I. TEST OBJECTIVE

The objective of this test is to establish the time required to replace and/or repair selected subsystems.

1.3-II. TEST DESCRIPTION

The test involved components that may be expected to fail or require replacement during the service life of the bus. In addition, any component that failed during testing of the bus was added to this list. Components to be included are:

1. Transmission
2. Alternator
3. Starter
4. Batteries
5. Windshield wiper motor

1.3-III. DISCUSSION

At the end of the test, the items on the list were removed and replaced. The transmission assembly took 3.0 labor-hours (2 persons @ 1.5 hrs) to remove and replace. The time required for repair/replacement of the other four components is given on the following Repair and/or Replacement Form.

REPLACEMENT AND/OR REPAIR FORM

Subsystem	Replacement Time
Transmission	3.0 labor hours
Wiper Motor	0.5 labor hours
Starter	0.5 labor hours
Alternator	1.0 labor hours
Batteries	0.5 labor hours

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS



**TRANSMISSION REMOVAL AND REPLACEMENT
(3.0 LABOR HOURS)**

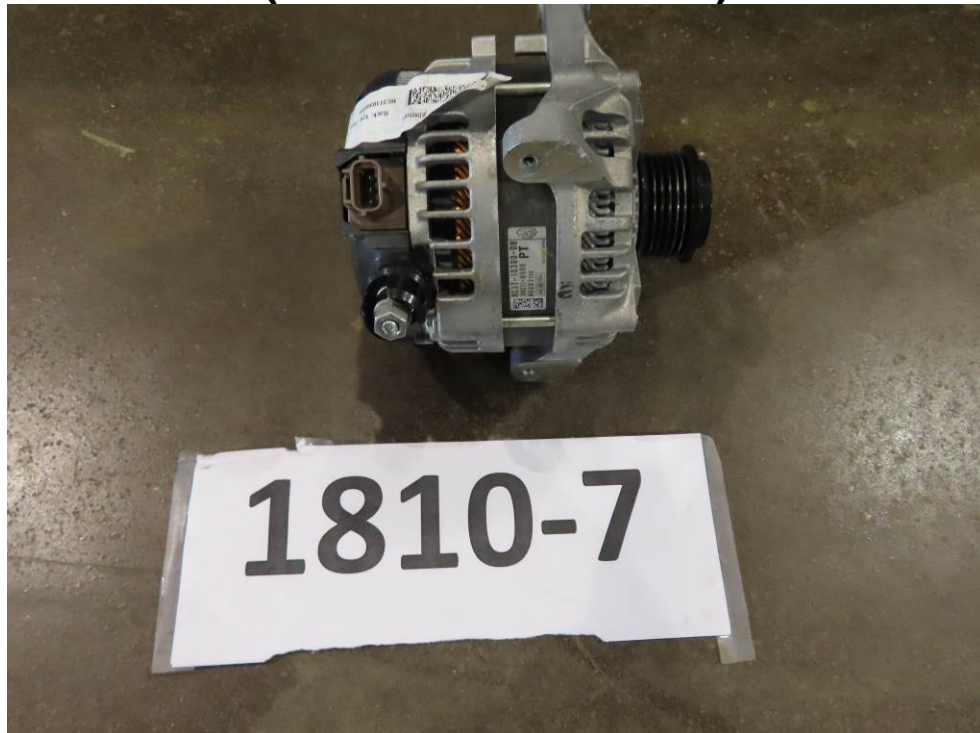


**WIPER MOTOR REMOVAL AND REPLACEMENT
(0.5 LABOR HOURS)**

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS CONT.



**STARTER REMOVAL AND REPLACEMENT
(0.5 LABOR HOURS)**



**ALTERNATOR REMOVAL AND REPLACEMENT
(1.0 LABOR HOURS)**

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 no Class 1, 2 or 4 failures. There were three Class 3 failures, one involved the engine, one involved the body and one involved the frame. These failures are available for review in the Unscheduled Maintenance List, located in Section 5.7 Structural Durability.

This bus passed the Structural and Powertrain Durability sections of the test.

RELIABILITY DATA FORMS

Bus Number : 1810	Date: 01-25-19
Personnel: B.L.	

Failure Type			
Class 4 Bad Order	Class 3 Bus Change	Class 2 Road Call	Class 1 Physical Safety

[illegible]

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, and therefore, passed this portion of the test.

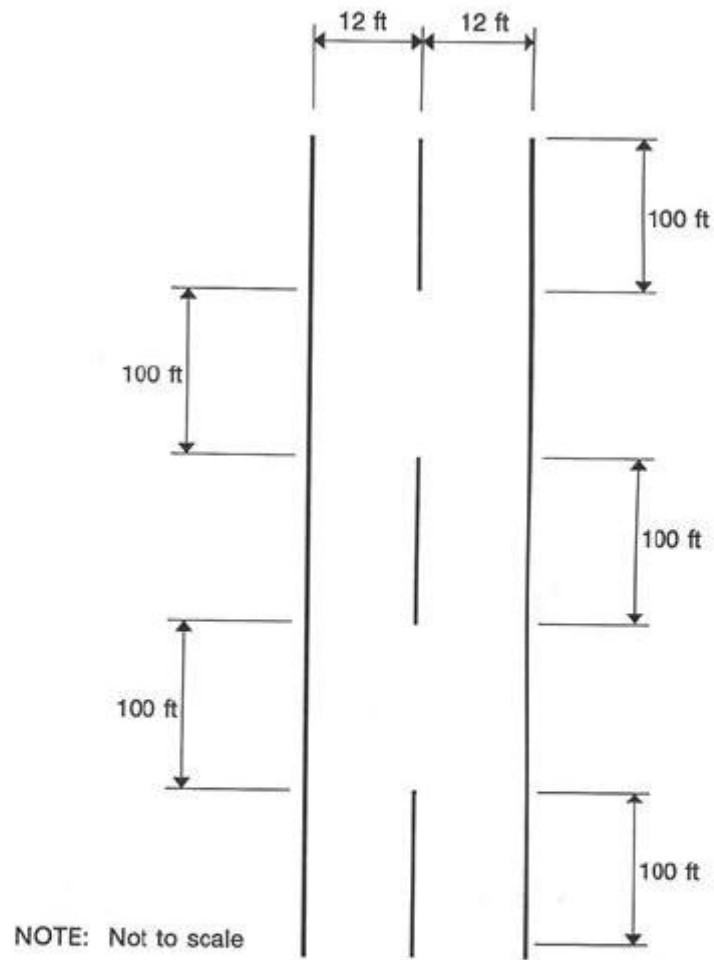


Figure 3.1. Double lane change test course

SAFETY DATA FORM

Page 1 of 1

Bus Number: 1810	Date: 10-26-18
Personnel: S.R., E.L., P.D. & F.T.	

Temperature (°F): 46	Humidity (%): 47
Wind Direction: ESE	Wind Speed (mph): 2
Barometric Pressure (in.Hg): 30.10	

SAFETY TEST: DOUBLE LANE CHANGE	
Maximum safe speed tested for double-lane change to left	45 mph
Maximum safe speed tested for double-lane change to right	45 mph
Comments of the position of the bus during the lane change:	
The test vehicle maintained a safe profile throughout all portions of testing.	
Comments of the tire/ground contact patch:	
The test vehicle maintained the tire/ground contact patch throughout all portions of testing.	

3.1 SAFETY



RIGHT - HAND APPROACH



LEFT - HAND APPROACH

3.2 Safety - Braking

3.2 I. TEST OBJECTIVE

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

3.2 II. TEST DESCRIPTION

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

The brake testing procedure is comprised of three phases:

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

3.2-III. DISCUSSION

The results of the Stopping Distance phase of the Brake Test are available in table 3.2-2. There was no deviation from the test lane during the performance of the Stopping Distance phase. The bus passed this portion of the test.

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

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

This bus passed all three phases of the Safety –Braking Test.

Table 3.2-1. Braking Test Data Forms

Page 1 of 3

Bus Number: 1810	Date: 10-19-18
Personnel: S.R. & E.D.	
Amb. Temperature (°F): 52	Wind Speed (mph): 10
Wind Direction: SSW	Pavement Temp (°F) Start: 60 End: 63

TIRE INFLATION PRESSURE (psi):				
Tire Type: Front: Continental HSR 225 70R19.5				
Rear: Continental HSR 225 70R19.5				
	Left Tire(s)		Right Tire(s)	
Front	95		95	
	Inner	Outer	Inner	Outer
Middle	N/A	N/A	N/A	N/A
Rear	110	110	110	110

AXLE LOADS (lb.)		
	Left	Right
Front	2,240	2,830
Middle	N/A	N/A
Rear	7,000	6,780

Table 3.2-2. Stopping Distance Test Results Form
(longest stopping distance in each test condition in bold)

Stopping Distance (ft)					
Vehicle Direction	CW	CW	CCW	CCW	
Speed (mph)	Stop 1	Stop 2	Stop 3	Stop 4	Average
20 (dry)	25.12	23.97	23.15	24.20	24.11
30 (dry)	48.31	50.41	46.64	51.03	49.09
40 (dry)	80.32	84.49	81.60	81.11	81.88
45 (dry)	110.76	104.73	105.28	109.71	107.62
20 (wet)	26.37	28.37	29.65	25.55	27.48

Table 3.2-3. Stability Test Results Form

Stability Test Results (Split Friction Road surface)			
Vehicle Direction	Attempt	Did test bus stay in 12' lane? (Yes/No)	Comments
Driver side on high friction	1	Yes	None noted.
	2	Yes	None noted.
Driver side on low friction	1	Yes	None noted.
	2	Yes	None noted.

Table 3.2-4. Parking Brake Test Form

PARKING BRAKE (Fully Loaded) – GRADE HOLDING						
Vehicle Direction	Attempt	Hold Time (min)	Slide (in)	Roll (in)	Did Hold	No Hold
Front up	1	5:00	N/A	N/A	✓	
	2	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A
Front down	1	5:00	N/A	N/A	✓	
	2	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A

Table 3.2-5. Record of All Braking System Faults/Repairs.

Date	Fault/Repair	Description
10-19-18	None noted.	N/A

3.2 Safety - Bus Braking



**PARKING BRAKE TEST
PARKING BRAKE HELD FOR 5 MINUTES IN
BOTH 20% UP AND 20% DOWN POSITIONS**



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 safe speed of 79.7 mph. The calculated gradeability results are attached. The average time to reach 30 mph was 9.4seconds. The maximum gradeability at 10 mph was 16.21% and at 40 mph was 7.70%. This bus passed this section of the test.

PERFORMANCE DATA FORM

Page 1 of 1

Bus Number: 1810		Date: 12-05-18	
Personnel: F.T. & S.I.			
Temperature (°F): 87		Humidity (%): 46.3	
Barometric Pressure (in.Hg): 28.7			
		INITIALS:	
Air Conditioning - OFF	✓Checked	F.T.	
Ventilation fans - ON HIGH	✓ Checked	F.T.	
Heater pump motor - OFF	✓Checked	N/A	
Defroster - OFF	✓ Checked	F.T.	
Exterior and interior lights - ON	✓ Checked	F.T.	
Windows and doors - CLOSED	✓ Checked	F.T.	
ACCELERATION, GRADEABILITY, TOP SPEED			
Recorded Interval Times			
Speed	Run 1	Run 2	Run 3
10 mph	2.6	2.7	2.9
20 mph	5.3	5.8	6.1
30 mph	8.9	9.5	9.8
40 mph	14.3	14.8	15.2
50 mph	20.5	21.1	21.6
60 mph	30.0	30.5	31.1
70 mph	44.0	45.7	47.5

Maximum Speed (mph): 79.7(maximum safe dynamometer speed reached)

PERFORMANCE SUMMARY SHEET

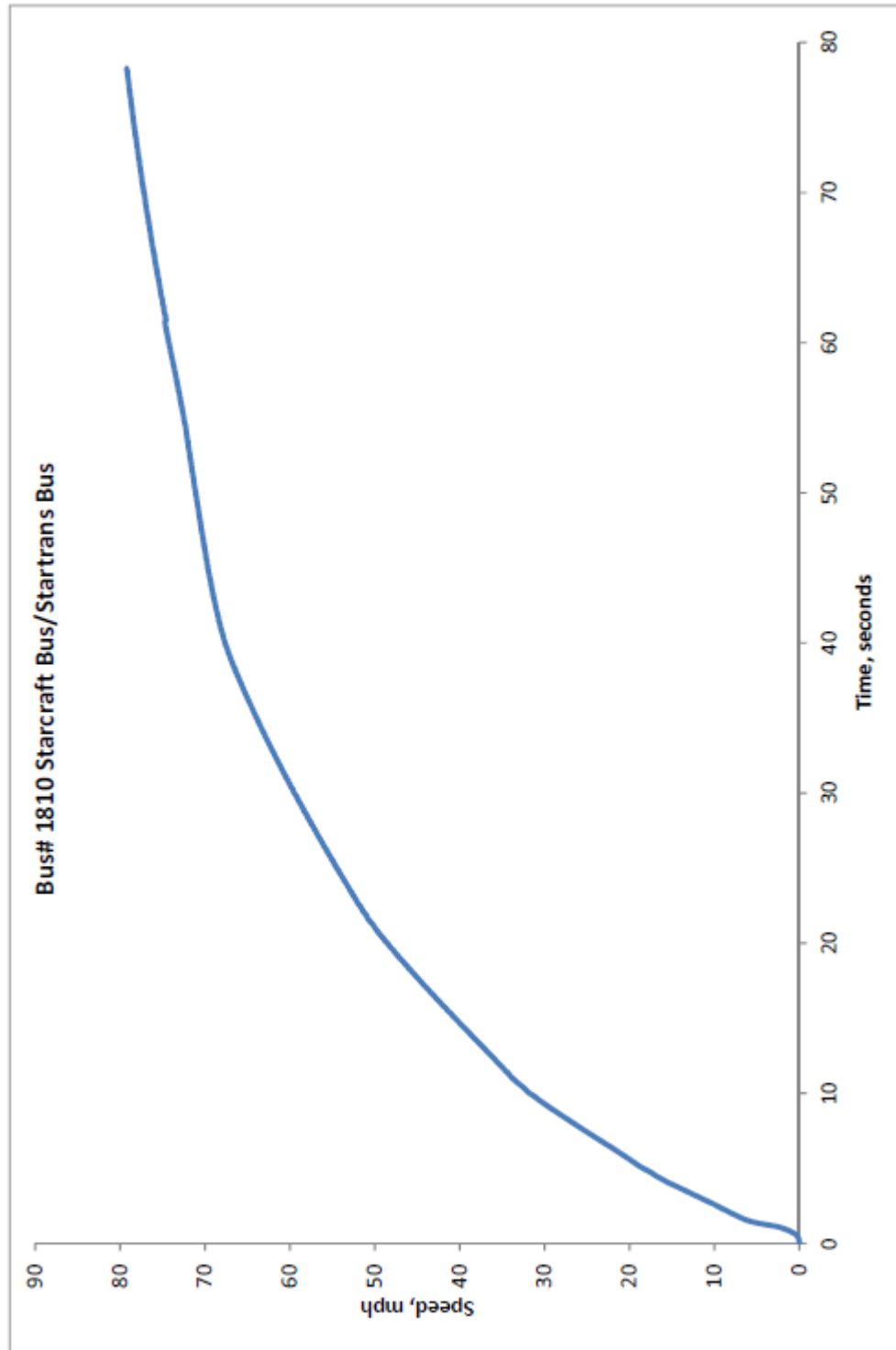
Bus Number: 1810	Date: 12-05-18
Personnel: F.T. & S.I.	

Test Conditions:

Temperature (°F): 87	Humidity (%): 46.3
Barometric Pressure (in.Hg): 28.7	

Test Results:

Vehicle Speed (MPH)	Time (SEC)	Acceleration (FT/SEC^2)	Max. Grade (%)
1.0	0.9	6.36	19.8
5.0	1.5	8.74	27.1
10.0	2.7	5.22	16.2
15.0	4.1	5.10	15.8
20.0	5.8	3.90	12.1
25.0	7.6	4.01	12.5
30.0	9.4	3.67	11.4
35.0	11.9	2.45	7.6
40.0	14.8	2.48	7.7
45.0	17.9	2.35	7.3
50.0	21.2	1.98	6.2
55.0	25.7	1.51	4.7
60.0	30.8	1.36	4.2
65.0	36.5	1.16	3.6
70.0	46.3	0.40	1.2
75.0	62.8	0.49	1.5



5.2 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL DISTORTION

5.2-I. TEST OBJECTIVE

The objective of this test is to observe the operation of the bus subsystems when the bus is placed in a longitudinal twist simulating operation over a curb or through a pothole.

5.2-II. TEST DESCRIPTION

With the bus loaded to GVW, each wheel of the bus was raised (one at a time) to simulate operation over a curb and the following were inspected:

1. Body
2. Windows
3. Doors
4. Roof vents
5. Special seating
6. Undercarriage
7. Engine
8. Service doors
9. Escape hatches
10. Steering mechanism

Each wheel was then lowered (one at a time) to simulate operation through a pothole and the same items inspected.

5.2-III. DISCUSSION

The test sequence was repeated ten times. The first and last test is with all wheels level. The other eight tests are with each wheel 6 inches higher and 6 inches lower than the other three wheels.

All doors, windows, escape mechanisms, engine, steering and ADA accessible devices operated normally throughout the test. The undercarriage and body indicated no deficiencies. No water leakage was observed during the test. The results of this test are indicated on the following data forms. This bus passed this section of the test.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 1 of 10

Bus Number: 1810	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input checked="" type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 2 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 3 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 4 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 5 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input checked="" type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 6 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 7 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 8 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 9 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input checked="" type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

DISTORTION TEST INSPECTION FORM

(Note: Ten copies of this data sheet are required)

Page 10 of 10

Bus Number:	Date: 10-12-18
Personnel: T.S., S.R., E.L., J.P. & M.H.	Temperature(°F): 50

Wheel Position : (check one)		
All wheels level	<input type="checkbox"/> before	<input checked="" type="checkbox"/> after
Left front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right front	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left rear	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Right center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower
Left center	<input type="checkbox"/> 6 in higher	<input type="checkbox"/> 6 in lower

	Comments
Windows	No Deficiencies.
Front Doors	No Deficiencies.
Rear Doors	No Deficiencies.
Escape Mechanisms/ Roof Vents	No Deficiencies.
Engine	No Deficiencies.
ADA Accessible/ Special Seating	No Deficiencies.
Undercarriage	No Deficiencies.
Service Doors	No Deficiencies.
Body	No Deficiencies.
Windows/ Body Leakage	No Deficiencies.
Steering Mechanism	No Deficiencies.

5.2 STRUCTURAL DISTORTION TEST



RIGHT FRONT WHEEL SIX INCHES HIGHER



LEFT REAR WHEEL SIX INCHES LOWER

5.3 STRUCTURAL STRENGTH AND DISTORTION TESTS - STATIC TOWING TEST

5.3-I. TEST OBJECTIVE

The objective of this test is to determine the characteristics of the bus towing mechanisms under static loading conditions.

5.3-II. TEST DESCRIPTION

Utilizing a load-distributing yoke, a hydraulic cylinder was used to apply a static tension load equal to 1.2 times the bus curb weight. The load was applied to both the front and rear, if applicable, towing fixtures at an angle of 20 degrees with the longitudinal axis of the bus, first to one side then the other in the horizontal plane, and then upward and downward in the vertical plane. Any permanent deformation or damage to the tow eyes or adjoining structure was recorded.

5.3-III. DISCUSSION

The load-distributing yoke was incorporated as the interface between the Static Tow apparatus and the test bus tow hook/eyes. The test was performed to the full target test weight of 16,584 lb. (1.2 x 13,820 lb. CW). No damage or deformation was observed during all four pulls of the test.

STATIC TOWING TEST DATA FORM

Page 1 of 1

Bus Number: 1810	Date: 12-7-18
Personnel: S.R., J.P., P.D., F.T., M.H. & J.S.	Temperature (°F): 30

Inspect right front tow eye and adjoining structure.
Comments: No deformation or damage present following all four static towing configurations.
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: None noted.
Inspect left front tow eye and adjoining structure.
Comments: No deformation or damage occurred to the tow eye following each of the four towing configurations.
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: None noted.
Inspect right rear tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: None noted.
Inspect left rear tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: None noted.
General comments of any other structure deformation or failure:
No deformation or damage to note.

5.4 STATIC TOWING TEST



FRONT 20° DOWNWARD PULL



FRONT 20° UPWARD PULL

5.4 STRUCTURAL STRENGTH AND DISTORTION TESTS - DYNAMIC TOWING TEST

5.4-I. TEST OBJECTIVE

The objective of this test is to verify the integrity of the towing fixtures and determine the feasibility of towing the bus under manufacturer specified procedures.

5.4-II. TEST DESCRIPTION

This test required the bus to be towed at curb weight using the specified equipment and instructions provided by the manufacturer and a heavy-duty wrecker. The bus was towed for 5 miles at a speed of 20 mph for each recommended towing configuration. After releasing the bus from the wrecker, the bus was visually inspected for any structural damage or permanent deformation. All doors, windows and passenger escape mechanisms were inspected for proper operation.

5.4-III. DISCUSSION

The bus was towed using a heavy-duty wrecker. The towing interface was accomplished by incorporating a hydraulic under-lift. A front lift tow was performed. No problems, deformation, or damage was noted during testing. This bus passed this section of the test.

DYNAMIC TOWING TEST DATA FORM

Page 1 of 1

Bus Number: 1810	Date: 11-20-18
Personnel: E.D. & E.L.	

Temperature (°F): 36	
Wind Direction: W	Wind Speed (mph): 6

Inspect tow equipment-bus interface.
Comments: Adequate connection made using a wheel lift.
Inspect tow equipment-wrecker interface.
Comments: Adequate connection between tow equipment and wrecker.
Towing Comments: Full tow was accomplished.
Description and location of any structural damage: None noted.
General Comments: Full tow was done using a wheel lift.

5.4 DYNAMIC TOWING TEST



TOWING INTERFACE



TEST BUS IN TOW

5.5 STRUCTURAL STRENGTH AND DISTORTION TESTS – JACKING TEST

5.5-I. TEST OBJECTIVE

The objective of this test is to inspect for damage due to the deflated tire, and determine the feasibility of jacking the bus with a portable hydraulic jack to a height sufficient to replace a deflated tire.

5.5-II. TEST DESCRIPTION

With the bus at curb weight, the tire(s) at one corner of the bus were replaced with deflated tire(s) of the appropriate type. A portable hydraulic floor jack was then positioned in a manner and location specified by the manufacturer and used to raise the bus to a height sufficient to provide 3-in clearance between the floor and an inflated tire. The deflated tire(s) were replaced with the original tire(s) and the jack was lowered. Any structural damage or permanent deformation was recorded on the test data sheet. This procedure was repeated for each corner of the bus.

5.5-III. DISCUSSION

The jack used for this test has a minimum height of 8.75 inches. During the deflated portion of the test, the jacking point clearances ranged from 10.1 inches to 18.6 inches. No deformation or damage was observed during testing. A complete listing of jacking point clearances is provided in the Jacking Test Data Form. This bus passed this section of the test.

JACKING CLEARANCE SUMMARY

Condition	Frame Point Clearance
Front axle – one tire flat	18.1
Rear axle – one tire flat	12.0
Rear axle – two tires flat	10.1

JACKING TEST DATA FORM

Page 1 of 1

Bus Number: 1810	Date: 10-9-18
Personnel: E.D. & S.R.	Temperature (°F): 75

Record any permanent deformation or damage to bus as well as any difficulty encountered during jacking procedure.

I= Inflated D= Deflated

Deflated Tire	Jacking Pad Clearance Body/Frame (in)	Jacking Pad Clearance Axle/Suspension (in)	Comments
Right front	19.5" I 18.1" D	13.2" I 11.3" D	Frame/Axle
Left front	19.8" I 18.6" D	13.3" I 11.3" D	Frame/Axle
Right rear—outside	12.2" I 12.0" D	10.7" I 10.4" D	Body/Suspension
Right rear—both	12.2" I 10.1" D	10.7" I 9.0" D	Body/Suspension
Left rear—outside	13.0" I 12.6" D	10.8" I 10.5" D	Body/Suspension
Left rear—both	13.0" I 10.7" D	10.8" I 9.2" D	Body/Suspension
Right middle or tag—outside	N/A	N/A	N/A
Right middle or tag—both	N/A	N/A	N/A
Left middle or tag— outside	N/A	N/A	N/A
Left middle or tag— both	N/A	N/A	N/A
Additional comments of any deformation or difficulty during jacking:			
None noted.			

5.5 JACKING TEST



JACKING - FRONT



JACKING - REAR

5.6 STRUCTURAL STRENGTH AND DISTORTION TESTS - HOISTING TEST

5.6-I. TEST OBJECTIVE

The objective of this test is to determine possible damage or deformation caused by the jack/stands.

5.6-II. TEST DESCRIPTION

With the bus at curb weight, the front end of the bus was raised to a height sufficient to allow manufacturer-specified placement of jack stands under the axles or jacking pads independent of the hoist system. The bus was checked for stability on the jack stands and for any damage to the jacking pads or bulkheads. The procedure was repeated for the tag/middle axles (if equipped), and rear end of the bus. The procedure was then repeated for the front, tag/middle (if equipped) axles, and rear simultaneously.

5.6-III. DISCUSSION

The test was conducted using four posts of a six-post electric lift and 19 inch jack stands. The bus was hoisted from the front wheels and then from the rear wheels, and then from the front and rear wheels simultaneously and placed on jack stands.

The bus accommodated the placement of the vehicle lifts and jack stands and the procedure was performed without any instability noted. This bus passed this section of the test.

HOISTING TEST DATA FORM

Page 1 of 1

Bus Number: 1810	Date: 10-09-18
Personnel: S.R., E.D. & E.L.	Temperature (°F): 79

Comments of any structural damage to the jacking pads or axles while both the front wheels are supported by the jack stands:
None noted.
Comments of any structural damage to the jacking pads or axles while both the rear wheels are supported by the jack stands:
None noted.
Comments of any structural damage to the jacking pads or axles while both the tag axle wheels are supported by the jack stands:
N/A
Comments of any structural damage to the jacking pads or axles while the front, tag axle and rear wheels are supported by the jack stands:
None noted.
Comments of any problems or interference placing wheel hoists under wheels:
None noted.

5.6 HOISTING TEST



REAR OF BUS ON JACK STANDS



FRONT AND REAR OF BUS ON JACK STANDS

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 7,500 miles; approximately 5,000 miles on the LTI Durability Test Track and approximately 2,500 miscellaneous other miles. The test was conducted with the bus operated under three different loading conditions. The first segment consisted of approximately 3,000 miles with the bus operated at GVW, out of which 2,000 miles were completed on the durability track. The second segment consisted of approximately 1,500 miles with the bus operated at SLW, out of which 1,000 miles were completed on the durability track. The remainder of the test, approximately 3,000 miles, was conducted with the bus loaded to CW, with 2,000 of those miles being completed on the durability track. 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 October 12, 2018 and was conducted until December 10, 2018. The first 3,000 miles were performed at a GVW of 18,850 lb. and completed on October 26, 2018. The next 1,500 mile SLW segment was performed at 18,850 lb. and completed on November 5, 2018 and the final 3,000 mile segment was performed at a CW of 13,820 lb. and completed on December 10, 2018.

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. This bus passed this section of the test, as there were no uncorrected Class 1 or Class 2 failures and the unscheduled maintenance of 3.0 hours was less than 125 hours.

Starcraft Bus, Startrans Bus, Divisions of Forest River Bus # 1810

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
10/08/18 TO 10/14/18	90.00	63.00	153.00
10/15/18 TO 10/21/18	1033.00	419.00	1452.00
10/22/18 TO 10/28/18	877.00	436.00	1313.00
10/29/18 TO 11/04/18	826.00	272.00	1098.00
11/05/18 TO 11/11/18	627.00	222.00	849.00
11/12/18 TO 11/18/18	133.00	157.00	290.00
11/19/18 TO 11/25/18	571.00	235.00	806.00
11/26/18 TO 12/02/18	843.00	594.00	1437.00
12/03/18 TO 12/09/18	0.00	88.00	88.00
12/10/18 TO 12/16/18	0.00	60.00	60.00
Total	5000.00	2546.00	7546.00

Driving Schedule for Bus Operation on the Durability Test Track.

STANDARD OPERATING SCHEDULE

Monday through Friday

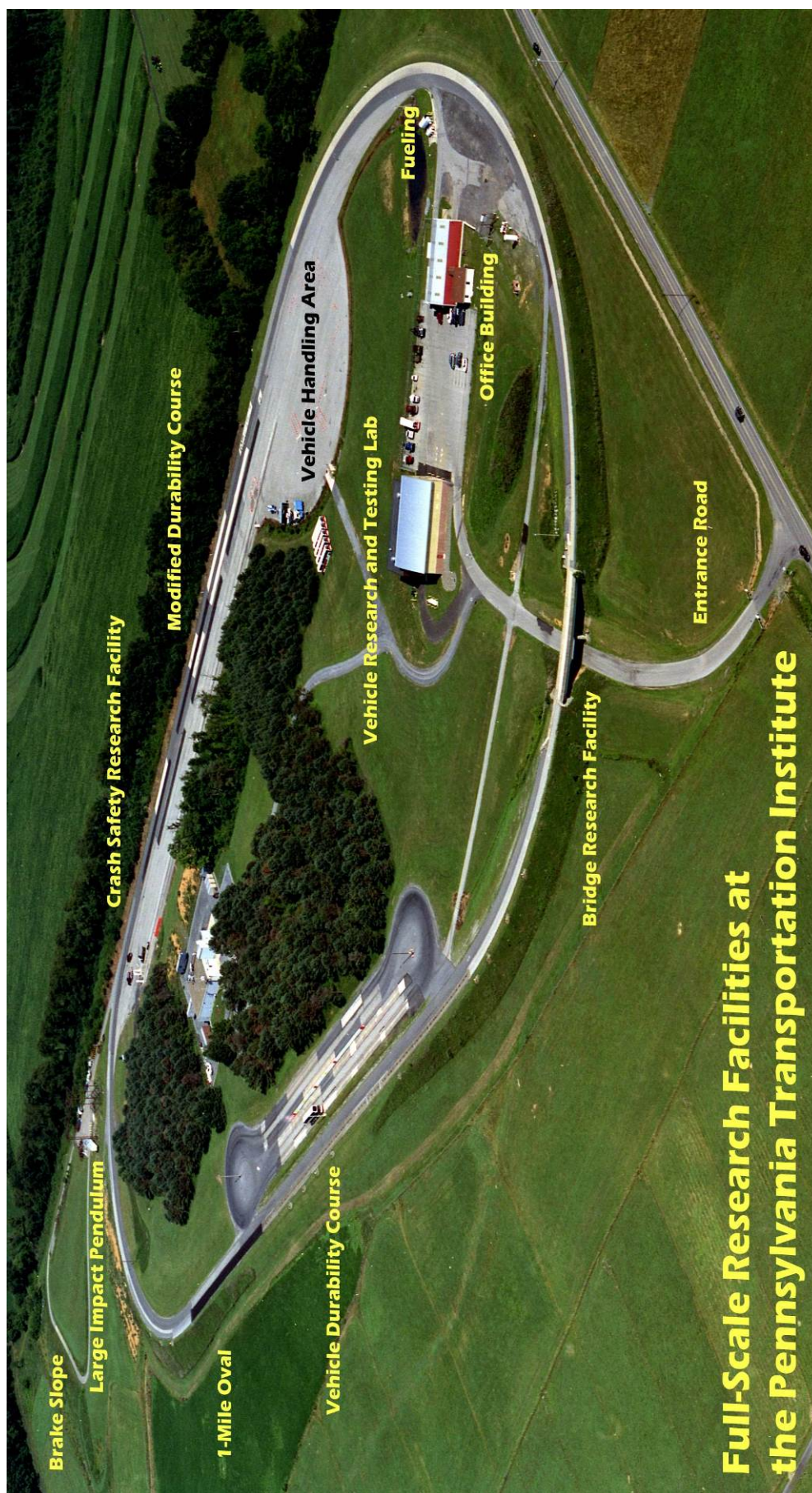
	HOUR	ACTION
Shift 1	midnight	D
	1:40 am	C
	1:50 am	B
	2:00 am	D
	3:35 am	C
	3:45 am	B
	4:05 am	D
	5:40 am	C
	5:50 am	B
	6:00 am	D
	7:40 am	C
	7:50 am	F
Shift 2	8:00 am	D
	9:40 am	C
	9:50 am	B
	10:00 am	D
	11:35 am	C
	11:45 am	B
	12:05 pm	D
	1:40 pm	C
	1:50 pm	B
	2:00 pm	D
	3:40 pm	C
	3:50 pm	F
Shift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

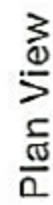
B—Break

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



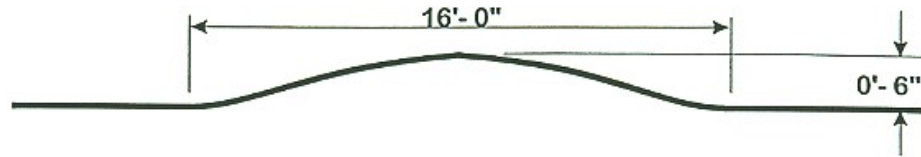


Track 1 (Track 2 has similar layout)

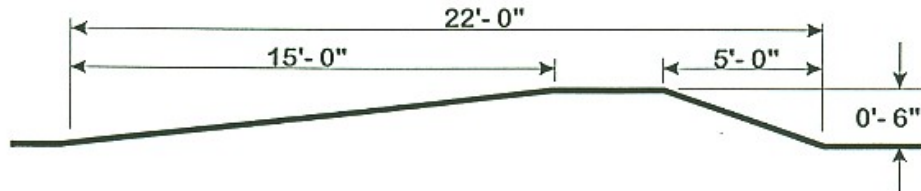
The Larson Transportation Institute

Penn State

Staggered
Bumps
(10 mph)



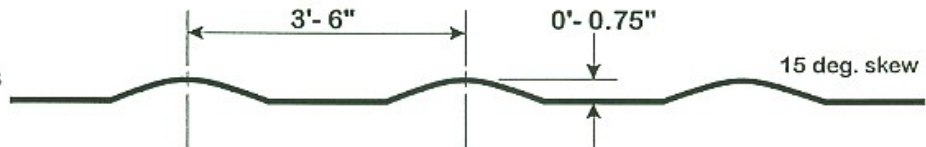
Railroad
Crossing
(8 mph)



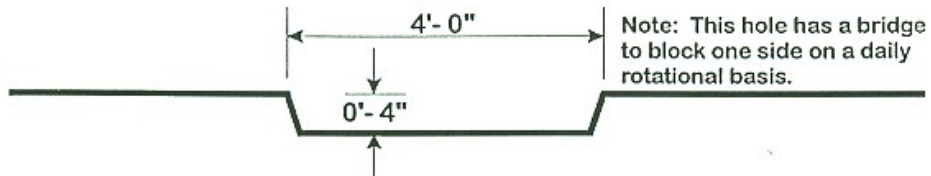
1" Random
Chuck Holes
(20 mph)



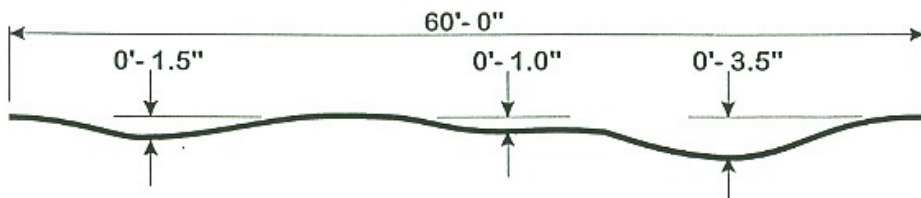
Chatter Bumps
(20 mph)



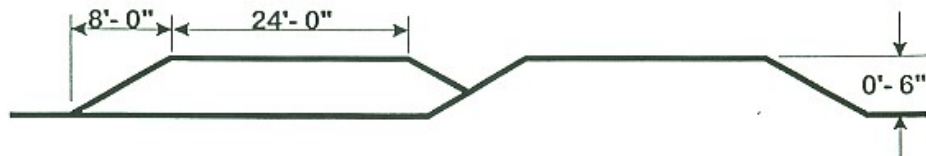
4" Chuck Hole
(5 mph)



High Crown
Intersection
(20 mph)



Frame Twist
(10 mph)



Durability Element Profiles

The Pennsylvania Transportation Institute
Penn State

(Page 1 of 1)
UNSCHEDULED MAINTENANCE
 Starcraft Bus, Startrans Bus, Divisions of Forest River Bus# 1810

DATE	TEST MILES	ISSUE	ACTION	LABOR HOURS	DOWN TIME
10-18-18	930	Check engine light is on.	Connected OBD II reader. Found codes P0171B (Bank 1 system too lean) and P0174B (Bank 2 system too lean)	0.50	0.50
11-08-18	4,865	Fiberglass cap loose behind driver's door.	Tightened and replaced screws on fiberglass cap behind driver's door.	0.50	1.00
11-14-18	4,865	Broken body mount (completely broken off at the weld)	Re-welded body mount in front of rear axle, left side.	2.00	3.00

UNSCHEDULED MAINTENANCE



**BROKEN BODY MOUNT WELD – FRONT OF REAR AXLE,
LEFT SIDE
(4,865 TEST MILES)**



**BODY MOUNT REWELDED – FRONT OF REAR AXLE,
LEFTT SIDE
(4,865 TEST MILES)**

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 operating profile, under specified operating conditions that are typical of transit bus operation. The results of this test may not represent actual mileage in transit service, but will provide data that can be used by FTA Grantees to compare the efficiency of buses tested using this procedure.

6-II. TEST DESCRIPTION

This test was 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, a medium average speed transient urban cycle (Figure 2), and the EPA HD-UDDS Cycle, which consists of urban and highway driving segments (Figure 3). A fuel economy test was comprised of two runs for the three different driving cycles, and the average value was reported.

For gaseous fuels, like compressed natural gas (CNG), liquefied natural gas (LNG), cryogenic fuels, and other fuels in the vapor state, a calibrated gaseous 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 test will be recorded on the Fuel Economy Data Form.

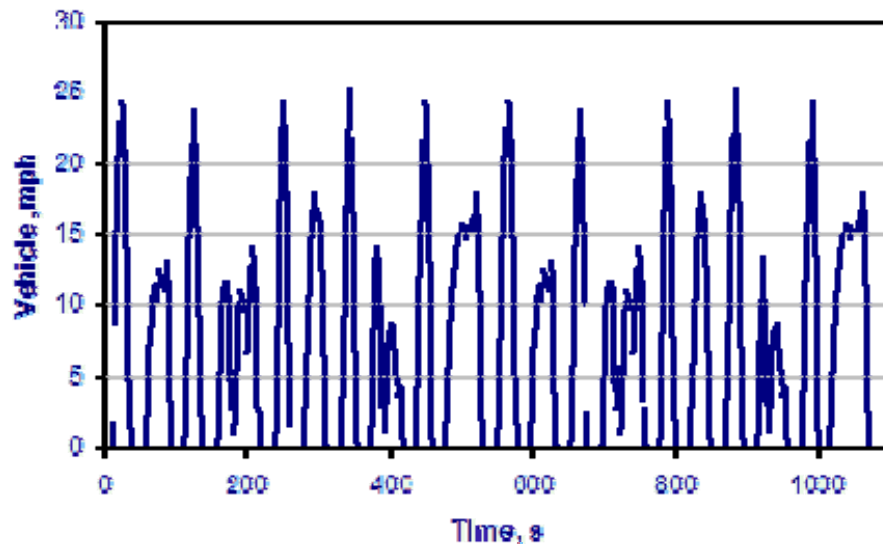


Figure 1. Manhattan Driving Cycle (duration 1089 sec, Maximum speed 25.4 mph, average speed 6.8 mph)

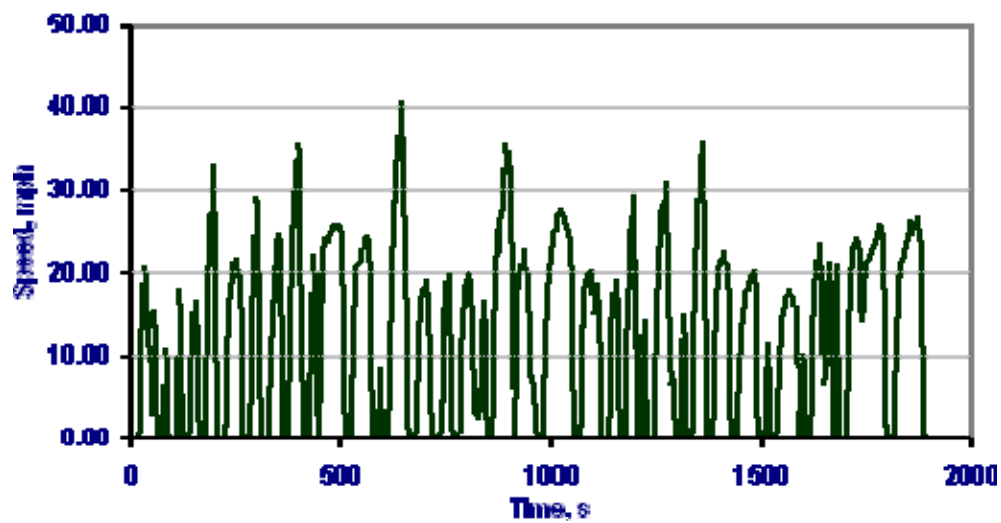


Figure 2. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41 mph, Average Speed 12 mph).

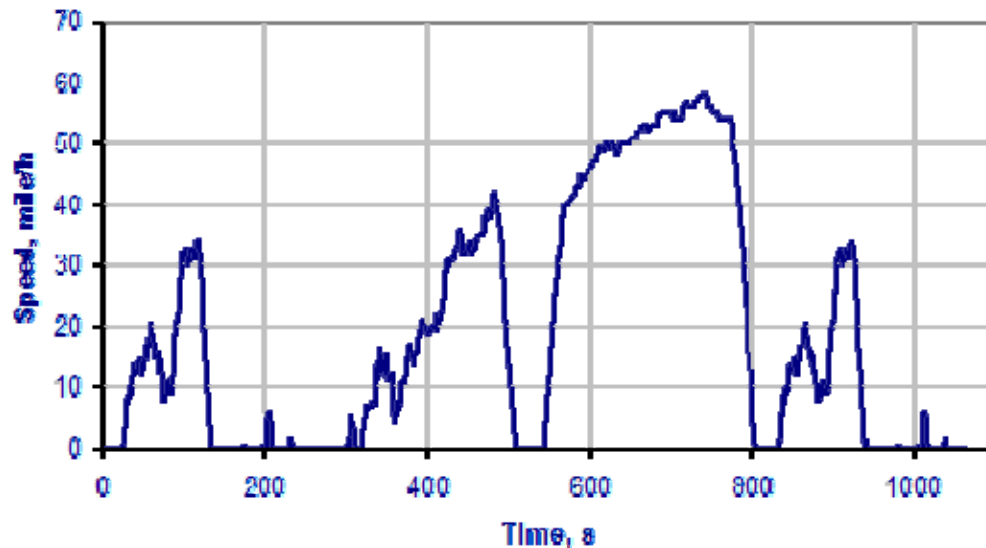


Figure 3. HD-UDDS Cycle (duration 1060 seconds, Maximum Speed 58 mph, Average Speed 18.86 mph).

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. The fuel consumption for each driving cycle and idle was measured.

An extensive pretest maintenance check was 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 Form. Finally, the summary sheet provides the average fuel consumption for the three test cycles and for a 20 minute idle. **The average fuel consumption for the Manhattan, OCBC and the HD-UDDS were 36.5 scf/mi, 25.8 scf/mi and 19.1 scf/mi respectively. For idle, the fuel consumption was 188.6 scf/hr.**

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Page 1 of 3

Bus Number: 1810	Date: 11-15-18	SLW (lb.): 18,850
Personnel: T.S., J.P., P.D. & S.R.		

FUEL SYSTEM	OK
Install fuel measurement system	✓
Replace fuel filter	N/A
Check for fuel leaks	✓
Specify fuel type (CNG)	✓
Remarks: Refer to manufacturer's maintenance specifications for fuel filter.	
BRAKES/TIRES	OK
Inspect hoses	✓
Inspect brakes	✓
Check tire inflation pressures (mfg. specs.)	✓
Check tire wear (less than 50%)	✓
Remarks: None noted.	
COOLING SYSTEM	OK
Check hoses and connections	✓
Check system for coolant leaks	✓
Remarks: None noted.	

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Page 2 of 3

Bus Number: 1810	Date: 11-15-18
Personnel: T.S., J.P. & P.D.	
ELECTRICAL SYSTEMS	OK
Check battery	✓
Inspect wiring	✓
Inspect terminals	✓
Check lighting	✓
Remarks: None noted.	
DRIVE SYSTEM	OK
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: Change fluid & filter every 150,000 miles as per manufacturer.	
LUBRICATION	OK
Drain crankcase oil	✓
Replace filters	✓
Replace crankcase oil	✓
Check for oil leaks	✓
Check oil level	✓
Lube all chassis grease fittings	✓
Lube universal joints	N/A
Replace differential lube including axles	N/A
Remarks: Refer to manufacturer's maintenance specifications for changing	
differential lube.	

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Page 3 of 3

Bus Number: 1810	Date: 11-15-18
Personnel: T.S., J.P. & P.D.	
EXHAUST/EMISSION SYSTEM	OK
Check for exhaust leaks	✓
Remarks: None noted.	
ENGINE	OK
Replace air filter	✓
Inspect air compressor and air system	N/A
Inspect vacuum system, if applicable	N/A
Check and adjust all drive belts	✓
Check cold start assist, if applicable	N/A
Remarks: None noted.	
STEERING SYSTEM	OK
Check power steering hoses and connectors	✓
Service fluid level	✓
Check power steering operation	✓
Remarks: None noted.	
	OK
Ballast bus to seated load weight	✓
TEST DRIVE	OK
Check brake operation	✓
Check transmission operation	✓
Remarks: None noted.	

FUEL ECONOMY PRE-TEST INSPECTION FORM

Page 1 of 1

Bus Number: 1810	Date: 12-5-18
Personnel: S.R., T.S., J.P. & F.T.	
PRE WARM-UP	If OK, Initial
Fuel Economy Pre-Test Maintenance Form is complete	S.R.
Cold tire pressure (psi): Front <u>95</u> Middle <u>N/A</u> Rear <u>110</u>	S.R.
Engine oil level	S.R.
Engine coolant level	S.R.
Fuel economy instrumentation installed and working properly.	S.R.
Fuel line -- no leaks or kinks	S.R.
Bus is loaded to SLW during coast down	S.R.
WARM-UP	If OK, Initial
Air conditioning off	F.T.
Exterior & Interior lights on	F.T.
Defroster off	F.T.
Windows and doors closed	F.T.
Do not drive with left foot on brake	F.T.

FUEL ECONOMY DATA FORM (Gaseous and Liquid fuels)

Page 1 of 1

Bus Number: 1810	Manufacturer: Starcraft	Date: 12-05-18
Fuel Type: CNG	Personnel: M.W. & S.I.	
Temperature (°F): 87	Humidity (%): 46.3	Barometric Pressure (in.Hg): 28.7
SLW (lb.): 18,850		

Cycle	Manhattan	Orange County	HD-UDDS	Idle
Fuel Consumption scf/mile	36.5	25.8	19.1	188.6 scf/hr

Comments: Engine goes on high idle (~1100 rpm) when in “park” and foot brake is released.

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 was measured at several locations with the bus operating under the following three conditions:

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

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

7.1-III. DISCUSSION

For the first part, the overall average of the six measurements was 45.6 dB(A); ranging from 44.4 dB(A) at the driver's seat to 46.7 dB(A) in line with the rear speaker. The interior ambient noise level for this test was less than 30 dB(A).

For the second part, the interior noise level ranged from 71.0 dB(A) at the middle passenger seats to 75.4 dB(A) at the driver's seat. The overall average was 72.5 dB(A). The interior ambient noise level for this test was less than 32 dB(A).

No vibrations or rattles were noted during the third part of this test. This bus passed this section of the test.

INTERIOR NOISE TEST DATA FORM

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

Page 1 of 3

Bus Number: 1810	Date: 11-06-18
Personnel: T.S. & M.H.	
Temperature (°F): 62	Humidity (%): 71
Wind Speed (mph): 9	Wind Direction: SSW
Barometric Pressure (in.Hg): 29.71	
Interior Ambient Noise Level dB(A): Less than 30	Exterior Ambient Noise Level dB(A): 44.3
Microphone Height During Testing (in):	

Reading Location	Measured Sound Level dB(A)
Driver's Seat	44.4
Front Passenger Seats	45.7
In Line with Front Speaker	44.5
In Line with Middle Speaker	46.5
In Line with Rear Speaker	46.7
Rear Passenger Seats	46.0

Comments: None noted.

INTERIOR NOISE TEST DATA FORM

Test Condition 2: 0 to 35 mph Acceleration Test

Page 2 of 3

Bus Number: 1810	Date: 11-06-18
Personnel: T.S., E.D. & F.T.	
Temperature (°F): 50	Humidity (%): 41
Wind Speed (mph): 9	Wind Direction: NNW
Barometric Pressure (in.Hg): 30.19	
Interior Ambient Noise Level dB(A): Less than 32	Exterior Ambient Noise Level dB(A): 43.7
Microphone Height During Testing (in): 46.0	

Reading Location	Measured Sound Level dB(A)
Driver's Seat	75.4
Front Passenger Seats	72.3
Middle Passenger Seats	71.0
Rear Passenger Seats	71.2

Comments: None noted.

INTERIOR NOISE TEST DATA FORM

Test Condition 3: Audible Vibration Test

Page 3 of 3

Bus Number: 1810	Date: 10-23-18
Personnel: T.S., S.R., E.D. & J.S.	
Temperature (°F): 58	

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

Source of Noise	Location	Description of Noise
Engine and Accessories	None noted.	None noted.
Windows and Doors	None noted.	None noted.
Seats and Wheel Chair lifts	None noted.	None noted.
Other	None noted.	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 was operated at a SLW in three different conditions using a smooth, straight and level roadway:

1. Accelerating at full throttle from a constant speed starting from 35 mph.
2. Accelerating at full throttle from standstill.
3. Stationary, with the engine at low idle, high idle, and wide open throttle, where applicable. In addition, the bus was tested with and without the air conditioning operating.

The test site is at the Larson Transportation Institute Test Track and the test procedures were performed 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 was used to measure the noise level.

During the test, special attention was 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 outside ambient noise level of 42.1 dB(A), the average of the two highest readings obtained while accelerating from a constant speed was 71.0 dB(A) on the right side and 71.1 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 41.1 dB(A), the average of the two highest readings obtained were 76.6 dB(A) on the right side and 77.2 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 54.2 dB(A) at low idle and 68.8 dB(A) at wide open throttle. With the accessories and air conditioning off, the readings averaged 54.0 dB(A) at low idle, 55.3 at high idle and 68.8 dB(A) at wide open throttle. The exterior ambient noise level measured during this test was 43.0 dB(A). This bus passed this section of the test.

EXTERIOR NOISE TEST DATA FORM

Accelerating from Constant Speed

Page 1 of 3

Bus Number: 1810		Date: 10-25-18	
Personnel: T.S., S.R., E.D. & F.T.			
Temperature (°F): 50		Humidity (%): 41	
Wind Speed (mph): 4		Wind Direction: NNW	
Barometric Pressure (in.Hg): 30.19			
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■			
Initial Sound Level Meter Calibration: 93.8 dB(A)			
Exterior Ambient Noise Level: 42.1 dB(A)			
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	71.0	1	70.6
2	70.1	2	70.9
3	70.3	3	71.1
4	70.6	4	70.6
5	71.0	5	71.1
6	N/A	6	N/A
7	N/A	7	N/A
8	N/A	8	N/A
9	N/A	9	N/A
10	N/A	10	N/A
Average of two highest actual noise levels = 71.0 dB(A)		Average of two highest actual noise levels = 71.1 dB(A)	
Final Sound Level Meter Calibration Check: 93.8 dB(A)			
Comments: None noted.			

EXTERIOR NOISE TEST DATA FORM

Accelerating from Standstill

Page 2 of 3

Bus Number: 1810		Date: 10-25-18	
Personnel: T.S., S.R., E.D. & F.T.			
Temperature (°F): 49		Humidity (%): 43	
Wind Speed (mph): 5		Wind Direction: NNW	
Barometric Pressure (in.Hg): 30.19			
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■			
Initial Sound Level Meter Calibration: 93.8 dB(A)			
Exterior Ambient Noise Level: 41.1 dB(A)			
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	75.9	1	77.4
2	76.3	2	74.0
3	76.8	3	75.3
4	76.0	4	76.6
5	75.9	5	76.9
6	N/A	6	N/A
7	N/A	7	N/A
8	N/A	8	N/A
9	N/A	9	N/A
10	N/A	10	N/A
Average of two highest actual noise levels = 76.5 dB(A)		Average of two highest actual noise levels = 77.1 dB(A)	
Final Sound Level Meter Calibration Check: 93.8 dB(A)			
Comments: None noted.			

EXTERIOR NOISE TEST DATA FORM

Stationary

Page 3 of 3

Bus Number: 1810		Date: 10-25-18	
Personnel: T.S., S.R., E.D. & F.T.			
Temperature (°F): 49		Humidity (%): 42	
Wind Speed (mph): 5		Wind Direction: NNW	
Barometric Pressure (in.Hg): 30.19			
Initial Sound Level Meter Calibration: 93.8 dB(A)			
Exterior Ambient Noise Level: 43.0 dB(A)			
Air Conditioning ON			
Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	720	54.6	53.8
High Idle	N/A	N/A	N/A
Wide Open Throttle	3700	68.4	69.1
Air Conditioning OFF			
Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	1140	52.9	55.0
High Idle	1342	54.4	56.2
Wide Open Throttle	3765	67.9	69.7
Final Sound Level Meter Calibration Check: 93.8 dB(A)			
Comments: With accessories off, high idle was achieved by taking foot off of service brake. This high idle feature was not available with accessories switched on.			

7.2 EXTERIOR NOISE TESTS



TEST BUS UNDERGOING EXTERIOR NOISE TESTING

8.0 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 on an engine by itself on a dynamometer operating under the Federal Test Protocol.

The Bus Testing Center emissions test is a measurement of the gaseous engine emissions CO, CO₂, NO_x, HC and particulates (diesel vehicles) produced by a complete 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 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 the emissions of buses tested under a range of consistent operating conditions.

8-II. TEST DESCRIPTION

This test was 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 emissions laboratory provides capability for testing heavy-duty diesel, gasoline, 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 dilution tunnel and a constant volume sampling (CVS) emissions measurement 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 was performed as soon as practical 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, a medium average speed transient urban cycle (Figure 2), and the EPA HD-UDDS Cycle, which consists of urban and highway driving segments (Figure 3). An emissions test was comprised of two runs for each of the three different driving cycles, and the average values were reported.

Test results reported include the average grams per mile value for each of the gaseous emissions of carbon dioxide, carbon monoxide, oxides of nitrogen, total hydrocarbons and non-methane hydrocarbons. In addition, emissions of particulate matter will also be reported for diesel fuel 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.

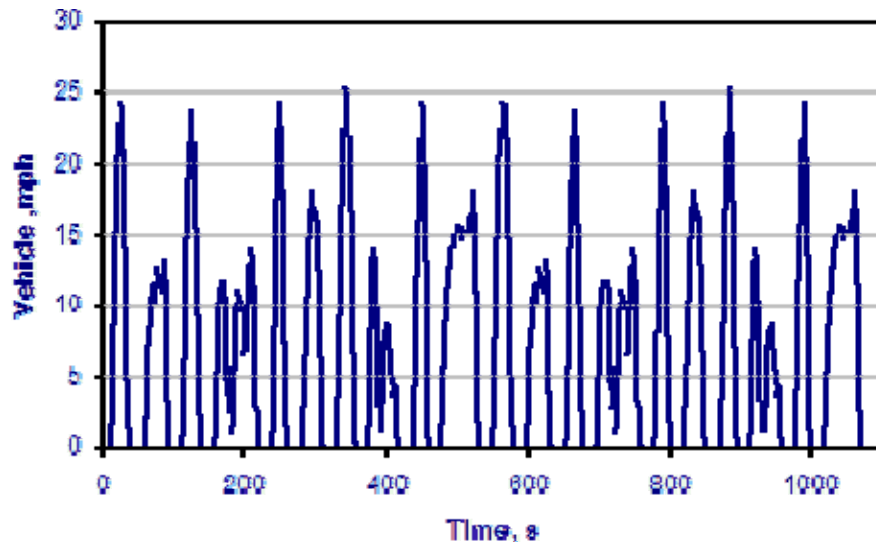


Figure 8.1. Manhattan Driving Cycle (Duration 1089 sec, Maximum Speed 25.4 mph, Average Speed 6.8 mph)

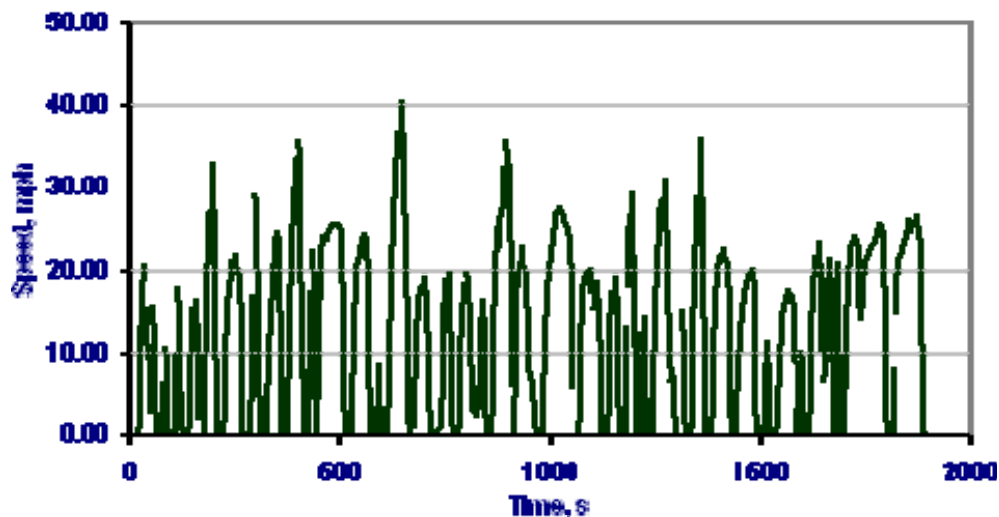


Figure 8.2. Orange County Bus Cycle (Duration 1909 Sec, Maximum Speed 41 mph, Average Speed 12 mph)

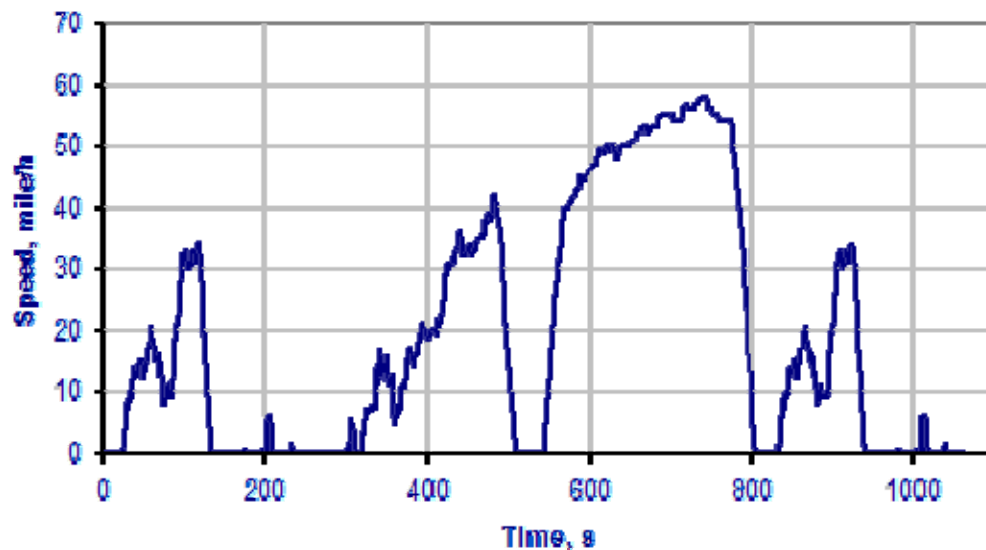


Figure 8.3. HD-UDDS Cycle (Duration 1060 seconds, Maximum Speed 58 mph, Average Speed 18.86 mph)

8-III. TEST ARTICLE

The test article is a Starcraft Bus, Startrans Bus, Divisions of Forest River, F-550 Allstar XL / F-550 Senator II model transit bus equipped with a CNG fueled Ford Motor Co. 6.8 L motor. The bus was tested on December 5, 2018 with the odometer reading 7,567 miles.

8-IV. TEST EQUIPMENT

Testing was 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 returned to the electrical grid.

Vehicle exhaust is collected by a Horiba CVS, full-flow dilution tunnel. The system has separate tunnels for diesel and gasoline/natural gas fueled vehicles. In the case of diesel vehicles, particulate emissions are measured gravimetrically using 47mm Teflon filters. These filters are housed in a Horiba HF47 particulate sampler, per EPA 1065 test procedures. Heated gaseous emissions of hydrocarbons and NO_x are sampled by Horiba heated oven analyzers.

Gaseous emissions for CO, CO₂ and cold NO_x are measured using a Horiba Mexa 7400 series gas analyzer. System operation, including the operation of the chassis dynamometer, and all calculations are controlled by a Dell workstation running Horiba CDCTS test control software. Particulate Filters are weighed in a glove box using a Sartorius microbalance accurate to 1 microgram.

8-V. TEST PREPARATION AND PROCEDURES

The test bus was 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 is 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 the Emissions test. Both the Fuel Economy Pre-Test Maintenance Form and the Fuel Economy Pre-Test Inspection Form are found in section 6, Fuel Economy Test.

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 consisted of driving the bus for 20 minutes at approximately 40 mph on the chassis dynamometer. During emissions testing, the test driver followed the prescribed driving cycle by watching the speed trace and instructions on the Horiba Drivers-Aid monitor which is placed in front of the windshield. The CDCTS computer monitored the test and collected data for calculation of emissions at the end of the test.

This bus was tested for emissions at seated load weight. The emissions data was obtained at the following conditions:

1. Air conditioning off
2. Heater off
3. Defroster off
4. Exterior and interior lights on
5. Windows and Doors closed
6. Seated load weight

The test tanks or the bus fuel tank(s) were filled prior to the fuel economy test with CNG.

8-VI DISCUSSION

Table 8.1 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 8.1 Emissions Test Results

Test Completed at SLW: 18,850 lb.			
Driving Cycle	Manhattan	Orange County Bus	UDDS
CO₂, gm/mi	2066	1414	1070
CO, gm/mi	0.24	0.15	0.16
THC, gm/mi	0.54	0.18	0.16
NMHC, gm/mi	0.03	0.01	0.01
NO_x, gm/mi	0.43	0.18	0.17

8. EMISSIONS TEST



BUS TESTED ON CHASSIS DYNAMOMETER FOR PERFORMANCE, FUEL ECONOMY AND EMISSIONS