STURAA TEST

12 YEAR

500,000 MILE BUS

from

PROTERRA, INC.

MODEL BE-35

April 2012

PTI-BT-R1107

PENNSTATE

The Thomas D. Larson
Pennsylvania Transportation Institute
Vehicle Systems and Safety Program

201 Transportation Research Building (814) 865-1891
The Pennsylvania State University
University Park, PA 16802

Bus Testing and Research Center

2237 Old Route 220 N. (814) 695-3404
Duncansville, PA 16635

A2LA ACCREDITED
MECHANICAL TESTING
CERTIFICATE 3172.01

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Proterra, Inc. submitted a model BE-35, electric-powered 38 seat (including the driver) 35-foot bus, for a 12 yr/500,000 mile STURAA test. The odometer reading at the time of delivery was 832 miles. Testing started on April 25, 2011 and was completed on March 5, 2012. The Check-In section of the report provides a description of the bus and specifies its major components.

The primary part of the test program is the Structural Durability Test, which also provides the information for the Maintainability and Reliability results. The Structural Durability Test was started on June 13, 2011 and was completed on February 17, 2012.

The interior of the bus is configured with seating for 38 passengers including the driver. Free floor space will accommodate 27 standing passengers resulting in a potential load of 65 persons. At 150 lbs per person, this load results in a measured Gross Vehicle Weight (GVW) of 37,320 lbs. **Note: at Gross Vehicle Load (GVL) the weight of the front axle is 1,270 lbs over the front GAWR, 390 lbs over the rear GAWR and 1,660 lbs over the GVWR.** The first segment of the Structural Durability Test was performed with the bus loaded to a GVW of 37,320 lbs. The middle segment was performed at a seated load weight of 33,320 lbs and the final segment was performed at a curb weight of 27,680 lbs. Durability driving resulted in unscheduled maintenance and failures that involved a variety of subsystems. A description of failures, and a complete and detailed listing of scheduled and unscheduled maintenance is provided in the Maintainability section of this report.

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

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.

The Reliability section compiles failures that occurred during Structural Durability Testing. Breakdowns are classified according to subsystems. The data in this section are arranged so that those subsystems with more frequent problems are apparent. The problems are also listed by class as defined in Section 2. The test bus encountered no Class 1 failures. Of the 38 reported failures, two were Class 2, 26 were Class 3 and 10 were Class 4.

The Safety Test, (a double-lane change, obstacle avoidance test) was safely performed in both right-hand and left-hand directions up to a maximum test speed of 45 mph. The performance of the bus is illustrated by a speed vs. time plot. Acceleration and gradeability test data are provided in Section 4, Performance. The average time to obtain 50 mph was 47.57 seconds. The Stopping Distance phase of the Brake Test was completed with the following results; for the Uniform High Friction Test average stopping distances were 31.97' at 20 mph, 68.81' at 30 mph, 125.75' at 40 mph and 171.23' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 30.66'. There was no deviation from the test lane during the performance of the Stopping Distance phase. During the Stability phase of Brake Testing the test bus experienced no deviation from the test lane but did experience pull to the left during both approaches to the Split Friction Road surface. The Parking Brake phase was completed with the test bus maintaining the parked position for the full five minute period with no slip or roll observed in both the uphill and downhill positions.

The Shakedown Test produced a maximum final loaded deflection of 0.165 inches with a permanent set ranging between -0.001 to 0.005 inches under a distributed static load of 23,325 lbs. The Distortion Test was completed with all subsystems, doors and escape mechanisms operating properly. Water leakage was observed throughout the test at the small, lower window on the front door, the window on the rear door and at the driver's sliding window.

The Static Towing Test was performed using a target load (towing force) of 33,216 lbs. All four front pulls were completed to the full test load with no damage or deformation observed. The Dynamic Towing Test was performed by means of a front-lift tow. The towing interface was accomplished using a hydraulic under-lift wrecker. The bus was towed without incident and no damage resulted from the test. The manufacturer does not recommend towing the bus from the rear, therefore, a rear test was not performed. The Jacking and Hoisting Tests were also performed without incident. The bus was found to be stable on the jack stands, and the minimum jacking clearance observed with a tire deflated was 3.2 inches.

A Fuel Economy Test was run on simulated central business district, arterial, and commuter courses. Refer to Section 6 Fuel Economy Test data.

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

ABBREVIATIONS

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

TEST BUS CHECK-IN

I. OBJECTIVE

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

II. TEST DESCRIPTION

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

III. DISCUSSION

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

The test bus consists of a Proterra, Inc., model BE-35 electric transit bus. The bus has a front door equipped with a Lift-U model LU11-12-05 foldout handicap ramp. Power is provided by a Proterra Fast Fill charging unit supplying power to the Proterra model BE-35 transit bus. Power is then supplied via Proterra model Terra Volt batteries to a UQM Technologies Inc., electric drive motor which is coupled to a Borg Warner model Proterra transmission.

The measured curb weight is 12,250 lbs for the front axle and 15,430 lbs for the rear axle. These combined weights provide a total measured curb weight of 27,680 lbs. There are 38 seats (6 stow for 2 wheelchair positions) including the driver and room for 27 standing passengers bringing the total passenger capacity to 65, or 59 and 2 wheelchair positions. Gross load is 150 lb x 59 = 8,850 lbs. + 1,200 lbs (2 wheelchair positions) = 10,050 lbs. At full capacity, the measured gross vehicle weight is 37,320 lbs. **Note: at GVL the load is 1,270 lbs over the front GAWR, 390 lbs over the rear GAWR and 1,660 lbs over the GVWR.**

These test results were obtained prior to the accreditation of the lab on November 8, 2011; therefore, are not considered to be accredited in accordance with A2LA policy.

VEHICLE DATA FORM

Bus Number: 1107	Arrival Date: 4-25-11
Bus Manufacturer: Proterra, Inc.	Vehicle Identification Number (VIN): 1M9TG11J9BG816007
Model Number: BE-35	Date: 4-25-11
Personnel: E.D., E.L. & T.S.	

WEIGHT:

Individual Wheel Reactions:

Weights (lb)	Front Axle		Middle Axle		Rear Axle	
	Right	Left	Right	Left	Right	Left
CW	3,710	8,540	N/A	N/A	9,810	5,620
SLW	4,840	9,600	N/A	N/A	11,520	7,360
GVW	6,020	10,910	N/A	N/A	12,190	8,200

Total Weight Details:

Weight (lb)	CW	SLW	GVW	GAWR
Front Axle	12,250	14,440	16,930	15,660
Middle Axle	N/A	N/A	N/A	N/A
Rear Axle	15,420	18,880	20,390	20,000
Total	27,680	33,320	37,320	GVWR: 35,660

Dimensions:

Length (ft/in)	35 / 8.5
Width (in)	101.4
Height (in)	133.4
Front Overhang (in)	102.0
Rear Overhang (in)	90.5
Wheel Base (in)	236.0
Wheel Track (in)	Front: 86.3
	Rear: 77.6

Bus Number: 1107	Date: 4-25-11

CLEARANCES:

Lowest Point Outside Front Axle	Location: Steering mounting plate Clearance(in): 6.2
Lowest Point Outside Rear Axle	Location: Air bag mount Clearance(in): 7.1
Lowest Point between Axles	Location: Body Clearance(in): 8.1
Ground Clearance at the center (in)	8.1
Front Approach Angle (deg)	7.2
Rear Approach Angle (deg)	8.0
Ramp Clearance Angle (deg)	3.9
Aisle Width (in)	24.4
Inside Standing Height at Center Aisle (in)	Front – 89.9 Rear – 73.8

BODY DETAILS:

Body Structural Type			
Frame Material	Stainless steel cradle front & rear.		
Body Material	Composite		
Floor Material	Composite		
Roof Material	Composite		
Windows Type	■ Fixed	☐ Movable	
Window Mfg./Model No.	Taylor / AS3 DOT-61 M-6 tint		
Number of Doors	1 Front	1 Rear	
Mfr. / Model No.	Proterra w/Vapor Bus Hardware/Front-6006029814 Rear-5101034600		
Dimension of Each Door (in)	Front-78.9 x 32.8	Rear- 78.2 x 30.4	
Passenger Seat Type	■ Cantilever	☐ Pedestal	☐ Other (explain)
Mfr. / Model No.	American Seating / VR50-CR50		
Driver Seat Type	■ Air	☐ Spring	☐ Other (explain)
Mfr. / Model No.	Recaro / Ergo		
Number of Seats (including Driver)	38		

Bus Number: 1107	Date: 4-25-11

BODY DETAILS (Contd..)

Free Floor Space (ft^2)	42.4
Height of Each Step at Normal Position (in)	Front 1. 15.9 2. N/A 3. N/A 4. N/A
	Middle 1. N/A 2. N/A 3. N/A 4. N/A
	Rear 1. 17.6 2. N/A 3. N/A 4. N/A
Step Elevation Change - Kneeling (in)	2.8 front & rear

ENGINE

Type	☐ C.I.	☐ Alternate Fuel	
	☐ S.I.	■ Other (Electric motor)	
Mfr. / Model No.	UQM Technologies Inc. / SRM286-149-2		
Location	☐ Front	■ Rear	☐ Other (explain)
Fuel Type	☐ Gasoline	☐ CNG	☐ Methanol
	☐ Diesel	☐ LNG	■ Other (Electric)
Fuel Tank Capacity (indicate units)	N/A (Electric)		
Fuel Induction Type	☐ Injected	☐ Carburetion	
Fuel Injector Mfr. / Model No.	N/A		
Carburetor Mfr. / Model No.	N/A		
Fuel Pump Mfr. / Model No.	N/A		
Alternator (Generator) Mfr. / Model No.	N/A		
Maximum Rated Output (Volts / Amps)	N/A		
Air Compressor Mfr. / Model No.	Hydrovane / 0009-0010-07		
Maximum Capacity (ft^3 / min)	10 @ 3,200 rpm		
Starter Type	☐ Electrical	☐ Pneumatic	■ Other (N/A)
Starter Mfr. / Model No.	N/A		

Bus Number: 1107	Date: 4-25-11

TRANSMISSION

Transmission Type	☐ Manual	■ Automatic	
Mfr. / Model No.	Borg Warner / Proterra		
Control Type	☐ Mechanical	■ Electrical	☐ Other
Torque Converter Mfr. / Model No.	N/A		
Integral Retarder Mfr. / Model No.	N/A		

SUSPENSION

Number of Axles	2		
Front Axle Type	■ Independent	☐ Beam Axle	
Mfr. / Model No.	ZF Passau GmbH / RL75EC		
Axle Ratio (if driven)	N/A		
Suspension Type	■ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	2		
Mfr. / Model No.	Sachs / 481700004723		
Middle Axle Type	☐ Independent	☐ Beam Axle	
Mfr. / Model No.	N/A		
Axle Ratio (if driven)	N/A		
Suspension Type	☐ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	N/A		
Mfr. / Model No.	N/A		
Rear Axle Type	☐ Independent	■ Beam Axle	
Mfr. / Model No.	ZF Passau GmbH / AV132/80		
Axle Ratio (if driven)	9.82		
Suspension Type	■ Air	☐ Spring	☐ Other (explain)
No. of Shock Absorbers	4		
Mfr. / Model No.	Sachs / 471700005112		

Bus Number: 1107	Date: 4-25-11

WHEELS & TIRES

Front	Wheel Mfr./ Model No.	Alcoa / 060810 22.5 / 8.25
	Tire Mfr./ Model No.	Michelin / 305/70R 22.5
Rear	Wheel Mfr./ Model No.	Alcoa / 060810 22.5 / 8.25
	Tire Mfr./ Model No.	Michelin / 305/70R 22.5

BRAKES

Front Axle Brakes Type	☐ Cam	■ Disc	☐ Other (explain)
Mfr. / Model No.	Knorr / SN7		
Middle Axle Brakes Type	☐ Cam	☐ Disc	☐ Other (explain)
Mfr. / Model No.	N/A		
Rear Axle Brakes Type	☐ Cam	■ Disc	☐ Other (explain)
Mfr. / Model No.	Knorr / SB7		
Retarder Type	N/A		
Mfr. / Model No.	N/A		

HVAC

Heating System Type	☐ Air	■ Water	☐ Other
Capacity (Btu/hr)	41,000		
Mfr. / Model No.	Thermoking / REHM 6		
Air Conditioner	■ Yes	☐ No	
Location	Roof		
Capacity (Btu/hr)	81,000		
A/C Compressor Mfr. / Model No.	Thermoking / REHM 5		

STEERING

Steering Gear Box Type	Hydraulic gear (electric motor assist)
Mfr. / Model No.	TRW / TAS 85
Steering Wheel Diameter (in)	18.0
Number of turns (lock to lock)	3.75

Bus Number: 1107	Date: 4-25-11

OTHERS

Wheel Chair Ramps	Location: Front	Type: Foldout
Wheel Chair Lifts	Location: N/A	Type: N/A
Mfr. / Model No.	Lift-U / LU11-12-105	
Emergency Exit	Location: Door Roof hatch Windows	Number: 2 1 11

CAPACITIES

Fuel Tank Capacity (units)	N/A
Engine Crankcase Capacity (gallons)	N/A
Transmission Capacity (liters)	2.0 +/- 0.1
Differential Capacity (liters)	16.5
Cooling System Capacity (gallons)	23.75
Power Steering Fluid Capacity (gallons)	3.5

OTHERS

Battery Packs Mfr./Model No.	Proterra / Terra Volt

VEHICLE DATA FORM

Bus Number: 1107	Date: 4-25-11

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

Part Number	Description	Qty.
NA	NA	NA

COMPONENT/SUBSYSTEM INSPECTION FORM

Bus Number: 1105	Date: 4-25-11

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

CHECK - IN

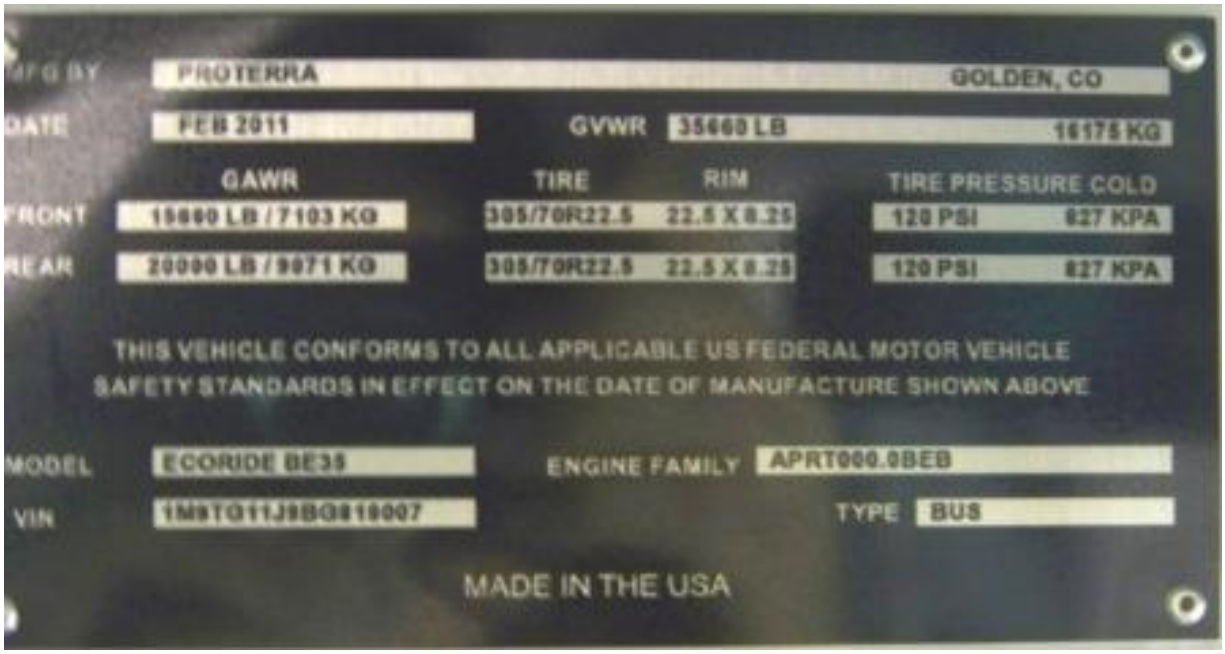
PROTERRA, INC.
MODEL BE-35

CHECK - IN CONT.

PROTERRA, INC.
MODEL BE-35 EQUIPPED WITH A LIFT-U MODEL LU11-12-05 FOLDOUT HANDICAP RAMP

CHECK - IN CONT.

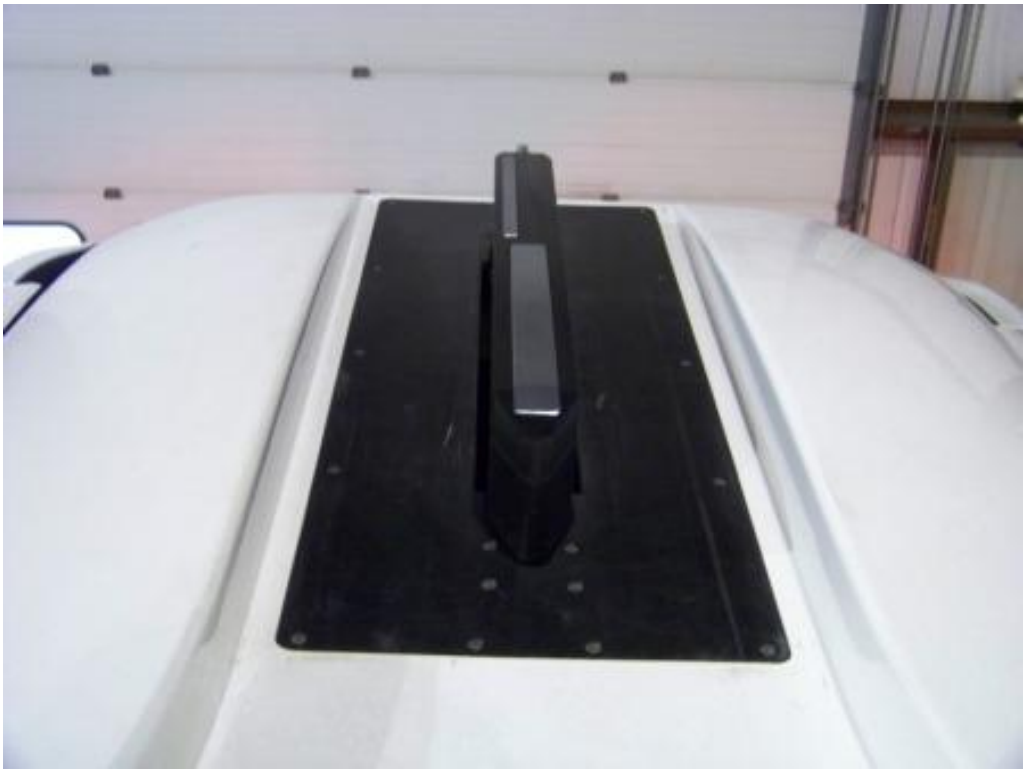
OPERATOR'S AREA



VIN TAG

CHECK - IN CONT.

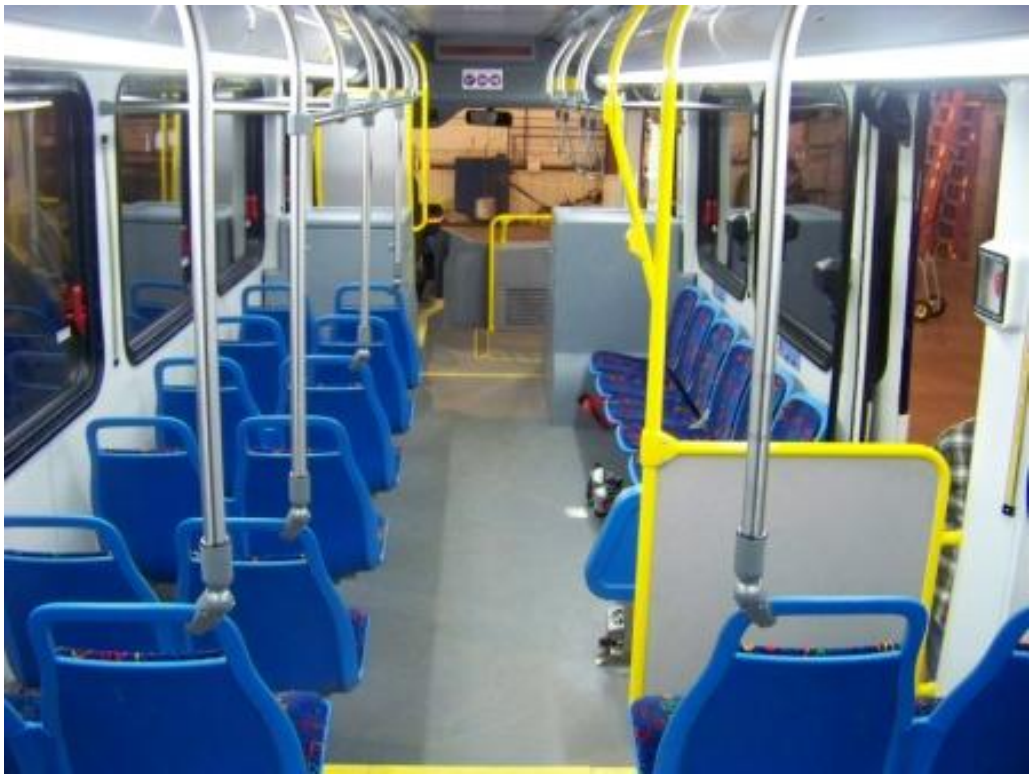
ENGINE COMPARTMENT



FASTFILL CHARGING INTERFACE

CHECK - IN CONT.

INTERIOR VIEW FROM FRONT



INTERIOR VIEW FROM REAR

CHECK - IN CONT.

UNDERCARRIAGE FORWARD

UNDERCARRAIGE AFT

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 is checked, and where accessibility is restricted the subsystem is 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

Bus Number: 1107	Date: 3-5-12

Component	Checked	Comments
ENGINE :		
Oil Dipstick	J.P.	N/A
Oil Filler Hole	J.P.	N/A
Oil Drain Plug	J.P.	N/A
Oil Filter	J.P.	N/A
Fuel Filter	J.P.	N/A
Air Filter	J.P.	N/A
Belts	J.P.	N/A
Coolant Level	J.P.	N/A
Coolant Filler Hole	J.P.	N/A
Coolant Drain	J.P.	N/A
Spark / Glow Plugs	J.P.	N/A
Alternator	J.P.	N/A
Diagnostic Interface Connector		
TRANSMISSION :		
Fluid Dip-Stick	J.P.	N/A
Filler Hole	J.P.	
Drain Plug	J.P.	
SUSPENSION :	J.P.	
Bushings	J.P.	
Shock Absorbers	J.P.	
Air Springs	J.P.	
Leveling Valves	J.P.	
Grease Fittings	J.P.	

ACCESSIBILITY DATA FORM

Bus Number: 1107	Date: 3-5-12

Component	Checked	Comments
HVAC :		
A/C Compressor	J.P.	
Filters	J.P.	
Fans	J.P.	
ELECTRICAL SYSTEM :		
Fuses	J.P.	
Batteries	J.P.	
Voltage regulator	J.P.	N/A
Voltage Converters	J.P.	N/A
Lighting	J.P.	
MISCELLANEOUS :		
Brakes	J.P.	
Handicap Lifts/Ramps	J.P.	
Instruments	J.P.	
Axles	J.P.	
Exhaust	J.P.	N/A
Fuel System	J.P.	N/A
OTHERS :		

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 will be conducted by operating the NBM and collecting the following data on work order forms and a driver log.

1. Unscheduled Maintenance
    a. Bus number
    b. Date
    c. Mileage
    d. Description of malfunction
    e. Location of malfunction (e.g., in service or undergoing inspection)
    f. Repair action and parts used
    g. Man-hours required

2. Scheduled Maintenance
    a. Bus number
    b. Date
    c. Mileage
    d. Engine running time (if available)
    e. Results of scheduled inspections
    f. Description of malfunction (if any)
    g. Repair action and parts used (if any)
    h. Man-hours required

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

A. Service
    1. Fueling
    2. Consumable checks
    3. Interior cleaning

B. Preventive Maintenance
    4. Brake adjustments
    5. Lubrication
    6. 3,000 mi (or equivalent) inspection

7. Oil and filter change inspection
8. Major inspection
9. 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

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. Table 1 is a list of the lubricating products used in servicing. Finally, the Unscheduled Maintenance List along with Unscheduled Maintenance-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 occurred, a description of the malfunction and repair, and the time required to perform the repair.

(Page 1 of 2)

SCHEDULED MAINTENANCE

Proterra #1107

DATE	TEST MILES	SERVICE	ACTIVITY	DOWN TIME	HOURS
07-12-11	1,259	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
08-29-11	2,007	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
09-22-11	3,644	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
10-12-11	4,916	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
10-26-11	5,785	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
11-07-11	6,660	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
11-30-11	7,627	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
12-08-11	8,638	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00

SCHEDULED MAINTENANCE

Proterra #1107

DATE	TEST MILES	SERVICE	ACTIVITY	DOWN TIME	HOURS
01-06-11	9,629	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
01-12-12	10,554	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
01-17-12	11,165	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
01-24-12	12,018	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
02-06-12	13,521	P.M. / Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
02-16-12	14,591	P.M./Inspection	Linkage, tie rods, universals/u-joints all lubed; all fluids checked.	4.00	4.00
02-21-12	15,000	P.M./Inspection Fuel Economy Prep	Linkage, tie rods, universals/u-joints all lubed. Oil changed. Oil filters changed. Transmission oil and filter changed	8.00	8.00

Table 1. STANDARD LUBRICANTS

The following is a list of Texaco lubricant products used in bus testing conducted by the Penn State University Altoona Bus Testing Center:

ITEM	PRODUCT CODE	TEXACO DESCRIPTION
Engine oil	#2112	URSA Super Plus SAE 30
Transmission oil	#1866	Automatic Trans Fluid Mercon/Dexron II Multipurpose
Gear oil	#2316	Multigear Lubricant EP SAE 80W90
Wheel bearing & Chassis grease	#1935	Starplex II

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 will involve components that may be expected to fail or require replacement during the service life of the bus. In addition, any component that fails during the NBM testing is 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

During the test, several additional components were removed for repair or replacement. Following is a list of components and total repair/replacement time.

	MAN HOURS
Rear, upper radius rod mounts.	9.00
Transmission isolators.	2.00
Transmission clutch speed sensor.	1.00
Left front transmission cross-member bushing.	3.00
5th passenger window, left.	3.00
Transmission/power train cradle.	15.00
Traction motor resistor.	2.00
6th passenger window, left.	2.00

At the end of the test, the remaining items on the list were removed and replaced. The transmission assembly took 8.00 man-hours (two men 4.00 hrs) to remove and replace. The time required for repair/replacement of the four remaining components is given on the following Repair and/or Replacement Form.

REPLACEMENT AND/OR REPAIR FORM

Subsystem	Replacement Time
Transmission	8.00 man hours
Wiper Motor	2.00 man hours
Drive Motor	4.00 man hours
Storage Battery Pack	0.50 man hours
Batteries (12 volt x 2)	0.50 man hours

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS

TRANSMISSION REMOVAL AND REPLACEMENT (8.00 MAN HOURS)

WIPER MOTOR REMOVAL AND REPLACEMENT (2.00 MAN HOURS)

1.3 REPLACEMENT AND/OR REPAIR OF SELECTED SUBSYSTEMS CONT.

DRIVE MOTOR REMOVAL AND REPLACEMENT (4.00 MAN HOURS)

STORAGE BATTERY PACK REMOVAL AND REPLACEMENT (0.50 MAN 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, man-hours to repair, and hours out of service are 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 passenger or driver injury and represents a severe crash situation.

(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 is accumulated during the Structural Durability Test. The following Reliability Data Form lists all unscheduled repairs under classes as defined above. These classifications are somewhat subjective as the test is performed on a test track with careful inspections every two hours. However, even on the road, there is considerable latitude on deciding how to handle many failures.

The Unscheduled Repair List is also attached to provide a reference for the repairs that are included in the Reliability Data Forms.

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 failures. The two Class 2 failures were the result of a failed drive motor and a broken output shaft in the transmission. Of the 26 Class 3 failures, ten involved the transmission/drive system, nine were electrical, three occurred in the suspension, two with the body/frame and one each with the steering and wheels/tires. These, and the remaining ten Class 4 failures are available for review in the Unscheduled Maintenance List, located in Section 5.7 Structural Durability.

RELIABILITY DATA FORMS
Page 1 of 2

Bus Number: 1107	Date: 02-23-12
Personnel: Bob Reifsteck	

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

Subsystems	Mileage	Mileage	Mileage	Mileage	Man Hours	Down Time
Drive System/ Transmission		377			4.00	48.00
		836			8.00	8.00
		2,167			4.00	144.00
	2,167				2.00	16.00
		2,219			1.00	14.00
		3,141			2.00	5.00
		3,644			3.00	48.00
	4,135				15.00	16.00
	5,071				1.00	1.00
		5,071			2.00	2.00
		5,071			4.00	55.00
		6,019			2.00	6.00
	6,202				6.00	48.00
		9,284			18.00	288.00
			13,977		40.50	76.00
			15,000		6.00	24.00
Electrical		2,007			2.00	16.00
		2,219			0.50	0.50
		2,258			1.00	22.00
	3,407				2.00	2.00
		3,644			1.00	4.00

Bus Number: 1107	Date: 02-23-12
Personnel: Bob Reifsteck	

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

Subsystems	Mileage	Mileage	Mileage	Mileage	Man Hours	Down Time
Electrical (continued)		5,064			1.00	1.00
		12,018			8.00	8.00
		12,910			2.00	2.00
		13,604			6.00	6.00
		13,855			18.00	23.00
Suspension	16				4.00	10.00
		197			9.00	164.00
		3,141			1.00	1.00
	5,824				8.00	8.00
		10,765			6.00	6.00
Wheels/Tires	4,135				3.00	1.00
		4,916			2.00	1.00
Windows/Doors	3,989				3.00	1.50
	6,669				2.00	2.00
Body/Frame		3,989			0.50	0.50
		6,202			4.00	2.00
Steering		10,554			1.00	4.00

3. SAFETY - A DOUBLE-LANE CHANGE (OBSTACLE AVOIDANCE)

3-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-II. TEST DESCRIPTION

The Safety Test is a vehicle handling and stability test. The bus will be operated at SLW on a smooth and level test track. The bus will be driven through a double lane change course at increasing speed until the test is considered unsafe or a speed of 45 mph is reached. The lane change course will be set up using pylons to mark off two 12 foot center to center lanes with two 100 foot lane change areas 100 feet apart. The bus will begin in one lane, change to the other lane in a 100 foot span, travel 100 feet, and return to the original lane in another 100 foot span. This procedure will be repeated, starting first in the right-hand and then in the left-hand lane.

3-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.

SAFETY DATA FORM

Bus Number: 1107	Date: 12-13-11
Personnel: J.S., S.C., T.S. & B.L.	

Temperature (°F): 42	Humidity (%): 41
Wind Direction: Calm	Wind Speed (mph): Calm
Barometric Pressure (in.Hg): 30.40	

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: A safe profile was maintained through all portions of testing.	
Comments of the tire/ground contact patch: Tire/ground contact was maintained through all portions of testing.	

3. SAFETY

RIGHT - HAND APPROACH

LEFT - HAND APPROACH

4.0 PERFORMANCE

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

4.1-I. TEST OBJECTIVE

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

4.1-II. TEST DESCRIPTION

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

4.1-III. DISCUSSION

This test consists of three runs in both the clockwise and counterclockwise directions on the Test Track. Velocity versus time data is obtained for each run and results are averaged together to minimize any test variability which might be introduced by wind or other external factors. The test was performed up to a maximum speed of 50 mph. The fitted curve of velocity vs. time is attached, followed by the calculated gradeability results. The average time to obtain 50 mph was 47.57 seconds.

PERFORMANCE DATA FORM

Bus Number: 1107	Date: 12-13-11
Personnel: B.L., T.S., S.C. & J.S.	

Temperature (°F): 42	Humidity (%): 41
Wind Direction: Calm	Wind Speed (mph): Calm
Barometric Pressure (in.Hg): 30.40	

Air Conditioning compressor-OFF	✓Checked
Ventilation fans-ON HIGH	✓Checked
Heater pump motor-Off	✓Checked
Defroster-OFF	✓ Checked
Exterior and interior lights-ON	✓ Checked
Windows and doors-CLOSED	✓ Checked

ACCELERATION, GRADEABILITY, TOP SPEED

Counter Clockwise Recorded Interval Times

Speed	Run 1	Run 2	Run 3
10 mph	4.29	3.92	4.23
20 mph	11.35	10.98	11.26
30 mph	17.63	17.48	17.63
40 mph	30.69	30.76	30.51
Top Test Speed(mph) 50	49.01	48.57	48.98

Clockwise Recorded Interval Times

Speed	Run 1	Run 2	Run 3
10 mph	4.17	4.61	4.58
20 mph	10.76	12.45	12.33
30 mph	16.67	18.73	18.86
40 mph	29.11	29.55	29.70
Top Test Speed(mph) 50	42.80	51.36	44.70

1107.ACC

PERFORMANCE SUMMARY SHEET

BUS MANUFACTURER :PROTERRA
BUS MODEL :MODEL BE-35
BUS NUMBER :1107
TEST DATE :12/13/11

TEST CONDITIONS :

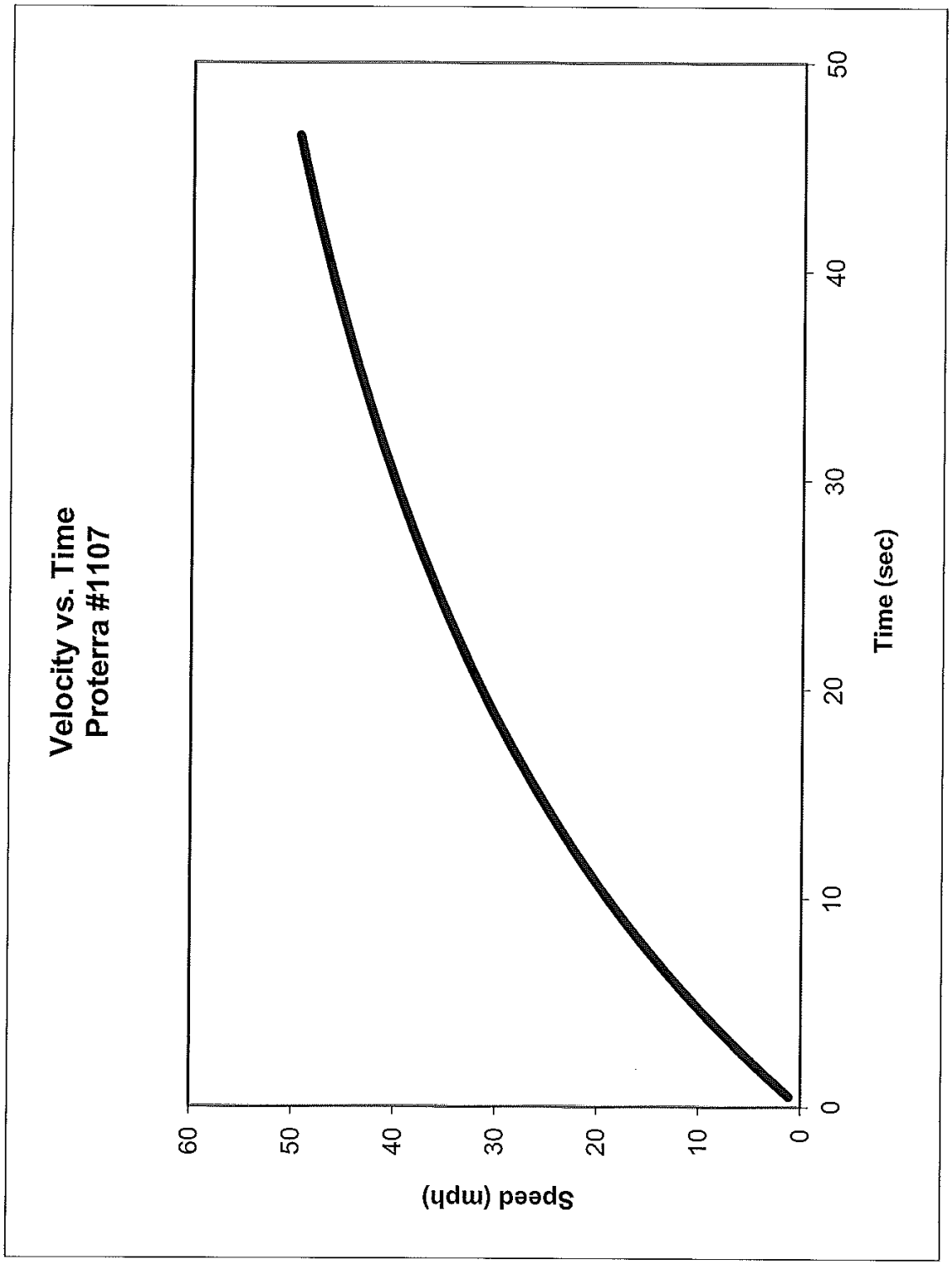
TEMPERATURE (DEG F) : 42.0
WIND DIRECTION : CALM
WIND SPEED (MPH) : .0
HUMIDITY (%) : 41
BAROMETRIC PRESSURE (IN. HG) : 30.4

VEHICLE SPEED	AVERAGE TIME (SEC)		
(MPH)	CCW DIRECTION	CW DIRECTION	TOTAL
10.0	4.45	4.15	4.30
20.0	11.85	11.20	11.52
30.0	18.09	17.58	17.83
40.0	29.45	30.65	30.05
50.0	46.29	48.85	47.57

TEST SUMMARY :

VEHICLE SPEED (MPH)	TIME (SEC)	ACCELERATION (FT/SEC^2)	MAX. GRADE (%)
1.0	.43	3.4	10.6
5.0	2.23	3.1	9.8
10.0	4.70	2.8	8.7
15.0	7.49	2.5	7.7
20.0	10.67	2.2	6.7
25.0	14.34	1.9	5.8
30.0	18.62	1.6	4.9
35.0	23.72	1.3	4.1
40.0	29.91	1.1	3.3
45.0	37.61	.8	2.6
50.0	47.52	.6	2.0

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


Velocity vs. Time
Proterra #1107
Speed (mph)
0
10
20
30
40
50
60
Time (sec)
0
10
20
30
40
50

4.0 PERFORMANCE

4.2 Performance - Bus Braking

4.2 I. TEST OBJECTIVE

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

4.2 II. TEST DESCRIPTION

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

The brake testing procedure comprises three phases:

1. Stopping distance tests

    i. Dry surface (high-friction, Skid Number within the range of 70-76)
    ii. Wet surface (low-friction, Skid Number within the range of 30-36)

2. Stability tests
3. Parking brake test

Stopping Distance Tests

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

The tests will be conducted as follows:

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

2. **Uniform Low Friction Tests:** Four maximum deceleration straight-line brake applications from 20 mph on a uniform low friction surface in a 3.66-m (12-ft) wide lane.

When performing service brake stops for both cases, the test vehicle is accelerated on the bus test lane to the speed specified in the test procedure and this speed is maintained into the skid pad area. Upon entry of the appropriate lane of the skid pad area, the vehicle's service brake is applied to stop the vehicle as quickly as

possible. The stopping distance is measured and recorded for both cases on the test data form. Stopping distance results on dry and wet surfaces will be recorded and the average of the four measured stopping distances will be considered as the measured stopping distance. Any deviation from the test lane will be recorded.

Stability Tests

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

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

Parking Brake Test

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

4.2-III. DISCUSSION

The Stopping Distance phase of the Brake Test was completed with the following results; for the Uniform High Friction Test average stopping distances were 31.97' at 20 mph, 68.81' at 30 mph, 125.75' at 40 mph and 171.23' at 45 mph. The average stopping distance for the Uniform Low Friction Test was 30.66' There was no deviation from the test lane during the performance of the Stopping Distance phase.

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

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

Table 4.2-6. Braking Test Data Forms

Bus Number: 1107	Date: 12/13/11
Personnel: J.S., B.L., S.C. & T.S.	
Amb. Temperature (^{o}F): 31	Wind Speed (mph): Calm
Wind Direction: Calm	Pavement Temp (°F) Start: 30 End: 33

TIRE INFLATION PRESSURE (psi):

Tire Type: Front: Michelin XZU 305/70R 22.5 Rear: Michelin XZU 305/70R 22.5

	Left Tire(s)		Right Tire(s)	
Front	120		120	
	Inner	Outer	Inner	Outer
Rear	120	120	120	120
Rear	N/A	N/A	N/A	N/A

AXLE LOADS (lb)

	Left	Right
Front	10,910	6,020
Rear	8,200	12,190

FINAL INSPECTION

Bus Number: 1107	Date: 12/13/11
Personnel: S.C.	

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

Date	Personnel	Fault/Repair	Description
12/13/11	S.C.	None noted.	

Table 4.2-8.1. Stopping Distance Test Results Form

Stopping Distance (ft)					
Vehicle Direction	CW	CW	CCW	CCW	
Speed (mph)	**Stop 1**	**Stop 2**	**Stop 3**	**Stop 4**	**Average**
20 (dry)	30.75	31.35	34.83	30.95	31.97
30 (dry)	75.59	75.10	65.68	58.85	68.81
40 (dry)	135.19	134.22	116.65	116.94	125.75
45 (dry)	170.56	184.66	168.25	161.44	171.23
20 (wet)	29.54	30.25	31.08	31.77	30.66

Table 4.2-8.2. Stability Test Results Form

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

Table 4.2-8.3. Parking Brake Test Form

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

5. STRUCTURAL INTEGRITY

5.1 STRUCTURAL STRENGTH AND DISTORTION TESTS - STRUCTURAL SHAKEDOWN TEST

5.1-I. DISCUSSION

The objective of this test is to determine certain static characteristics (e.g., bus floor deflection, permanent structural deformation, etc.) under static loading conditions.

5.1-II. TEST DESCRIPTION

In this test, the bus will be isolated from the suspension by blocking the vehicle under the suspension points. The bus will then be loaded and unloaded up to a maximum of three times with a distributed load equal to 2.5 times gross load. Gross load is 150 lb for every designed passenger seating position, for the driver, and for each 1.5 sq ft of free floor space. For a distributed load equal to 2.5 times gross load, place a 375-lb load on each seat and on every 1.5 sq ft of free floor space. The first loading and unloading sequence will "settle" the structure. Bus deflection will be measured at several locations during the loading sequences.

5.1-III. DISCUSSION

This test was performed based on a maximum passenger capacity of 59 people including the driver and 2 wheelchair positions. The resulting test load is (59 x 375 lb) = 22,125 lbs + 1,200 lbs (2 wheelchair positions) = 23,325 lbs. The load is distributed evenly over the passenger space. Deflection data before and after each loading and unloading sequence is provided on the Structural Shakedown Data Form.

The unloaded height after each test becomes the original height for the next test. Some initial settling is expected due to undercoat compression, etc. After each loading cycle, the deflection of each reference point is determined. The bus is then unloaded and the residual (permanent) deflection is recorded. On the final test, the maximum loaded deflection was 0.165 inches at reference point 7. The maximum permanent deflection after the final loading sequence ranged from -0.001 inches at reference point 10 to 0.005 inches at reference points 5, 7 & 12.

These test results were obtained prior to the accreditation of the lab on November 8, 2011; therefore, are not considered to be accredited in accordance with A2LA policy.

STRUCTURAL SHAKEDOWN DATA FORM

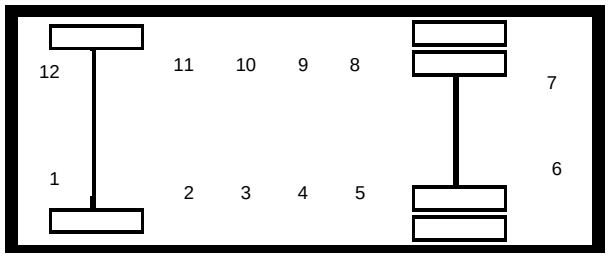
Bus Number: 1107	Date: 4-28-11
Personnel: T.S., E.D., P.D. & B.L.	Temperature (°F): 66
Loading Sequence: ■ 1 ☐ 2 ☐ 3 (check one) Test Load (lbs): 23,325 (32 seated, 27 standees & 2 W/C positions).	

Indicate Approximate Location of Each Reference Point

Right

Front of Bus

Left



Top View

Reference Point No.	A (in) Original Height	B (in) Loaded Height	B-A (in) Loaded Deflection	C (in) Unloaded Height	C-A (in) Permanent Deflection
1	0	-.068	-.068	.001	.001
2	0	.038	.038	.005	.005
3	0	.088	.088	.007	.007
4	0	.095	.095	.008	.008
5	0	.067	.067	.007	.007
6	0	.173	.173	.009	.009
7	0	.182	.182	.012	.012
8	0	.040	.040	.005	.005
9	0	.067	.067	.002	.002
10	0	.062	.062	.001	.001
11	0	.022	.022	.000	.000
12	0	-.065	-.065	-.008	-.008

STRUCTURAL SHAKEDOWN DATA FORM

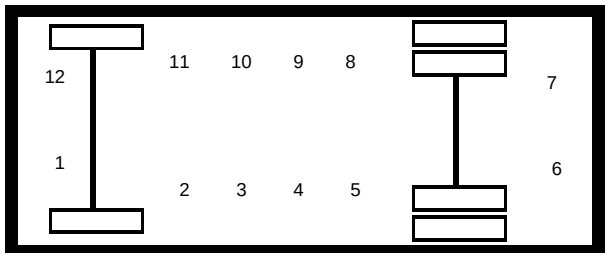
Bus Number: 1107	Date: 5-2-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature (°F): 65
Loading Sequence: ☐ 1 ■ 2 ☐ 3 (check one) Test Load (lbs): 23,325	

Indicate Approximate Location of Each Reference Point

Right

Front of Bus

Left



Top View

Reference Point No.	A (in) Original Height	B (in) Loaded Height	B-A (in) Loaded Deflection	C (in) Unloaded Height	C-A (in) Permanent Deflection
1	.001	.014	.013	.014	.013
2	.005	.042	.037	.006	.001
3	.007	.088	.081	.008	.001
4	.008	.094	.086	.008	.000
5	.007	.065	.058	.007	.000
6	.009	.159	.150	.023	.014
7	.012	.174	.162	.026	.014
8	.005	.044	.039	.006	.001
9	.002	.060	.058	.000	-.002
10	.001	.057	.056	.000	-.001
11	.000	.025	.025	.000	.000
12	-.008	.014	.022	.002	.010

STRUCTURAL SHAKEDOWN DATA FORM

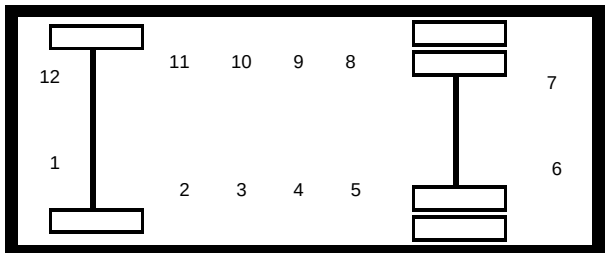
Bus Number: 1107	Date: 5-3-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature (°F): 64
Loading Sequence: ☐ 1 ☐ 2 ■ 3 (check one) Test Load (lbs): 23,325	

Indicate Approximate Location of Each Reference Point

Right

Front of Bus

Left



Top View

Reference Point No.	A (in) Original Height	B (in) Loaded Height	B-A (in) Loaded Deflection	C (in) Unloaded Height	C-A (in) Permanent Deflection
1	.013	.018	.005	.016	.003
2	.001	.044	.043	.005	.004
3	.001	.092	.091	.005	.004
4	.000	.096	.096	.004	.004
5	.000	.067	.067	.005	.005
6	.014	.169	.155	.018	.004
7	.014	.179	.165	.019	.005
8	.001	.043	.042	.002	.001
9	-.002	.060	.062	.001	.003
10	-.001	.057	.058	.000	-.001
11	.000	.026	.026	.001	.001
12	.010	.018	.008	.015	.005

5.1 STRUCTURAL SHAKEDOWN TEST

DIAL INDICATORS IN POSITION

BUS LOADED TO 2.5 TIMES GVL (23,325 LBS)

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 GVWR, each wheel of the bus will be raised (one at a time) to simulate operation over a curb and the following will be 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 will then be 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 handicapped devices operated normally throughout the test. The undercarriage and body indicated no deficiencies. Water leakage was observed throughout the test at the small, lower window on the front door, the window on the rear door and at the driver's sliding window. The results of this test are indicated on the following data forms.

These test results were obtained prior to the accreditation of the lab on November 8, 2011; therefore, are not considered to be accredited in accordance with A2LA policy.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	■ before	□ after
Left front	□ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	■ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	□ 6 in higher	□ 6 in lower
Right front	■ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	□ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	■ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	□ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	■ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	□ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	■ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	□ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	■ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	□ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	■ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	□ after
Left front	□ 6 in higher	■ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies.
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

DISTORTION TEST INSPECTION FORM
(Note: Ten copies of this data sheet are required)

Bus Number: 1107	Date: 5-6-11
Personnel: T.S., E.D., E.L. & B.L.	Temperature(°F): 62

Wheel Position : (check one)		
All wheels level	□ before	■ after
Left front	□ 6 in higher	□ 6 in lower
Right front	□ 6 in higher	□ 6 in lower
Right rear	□ 6 in higher	□ 6 in lower
Left rear	□ 6 in higher	□ 6 in lower

	Comments
■ Windows	No deficiencies.
■ Front Doors	Leak around small lower window.
■ Rear Doors	Leak around window.
■ Escape Mechanisms/ Roof Vents	No deficiencies.
■ Engine	No deficiencies.
■ Handicapped Device/ Special Seating	No deficiencies.
■ Undercarriage	No deficiencies
■ Service Doors	No deficiencies.
■ Body	No deficiencies.
■ Windows/ Body Leakage	Leak at driver's sliding window.
■ Steering Mechanism	No deficiencies.

5.2 STRUCTURAL DISTORTION TEST

RIGHT FRONT WHEEL SIX INCHES HIGHER

RIGHT FRONT 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 is used to apply a static tension load equal to 1.2 times the bus curb weight. The load will be 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 will be 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 33,216 lbs (1.2 x 27,680 lbs CW). No damage or deformation was observed during all four pulls of the test. The manufacturer does not recommend towing from the rear; therefore, a rear test was not performed.

STATIC TOWING TEST DATA FORM

Bus Number: 1107	Date: 2-28-12
Personnel: K.D., E.L., & B.G.	Temperature (°F): 45

Inspect right front tow eye and adjoining structure.
Comments: No damage or deformation observed.
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: Welds and bonding verified.
Inspect left tow eye and adjoining structure.
Comments: No damage or deformation observed.
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: Welds and bonding verified.
Inspect right rear tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: N/A
Inspect left rear tow eye and adjoining structure.
Comments: N/A
Check the torque of all bolts attaching tow eye and surrounding structure.
Comments: N/A
General comments of any other structure deformation or failure: All four front pulls were completed to the full target test load of 33,216 lbs (1.2 x 27,680 lbs CW), with no damage or deformation observed. The manufacturer does not recommend towing from the rear; therefore, a rear test was not performed.

5.3 STATIC TOWING TEST

FRONT 20° UPWARD PULL

FRONT 20° DOWNWARD PULL

5.3 STATIC TOWING TEST CONT.

FRONT 20° LEFT PULL

FRONT 20° LEFT 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 requires the bus be towed at curb weight using the specified equipment and instructions provided by the manufacturer and a heavy-duty wrecker. The bus will be towed for 5 miles at a speed of 20 mph for each recommended towing configuration. After releasing the bus from the wrecker, the bus will be visually inspected for any structural damage or permanent deformation. All doors, windows and passenger escape mechanisms will be 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. Rear towing is not recommended. No problems, deformation, or damage was noted during testing.

DYNAMIC TOWING TEST DATA FORM

Bus Number: 1107	Date: 2-3-12
Personnel: T.S.	

Temperature (°F): 37	Humidity (%): 56
Wind Direction: NW	Wind Speed (mph): 6
Barometric Pressure (in.Hg): 30.47	

Inspect tow equipment-bus interface.
Comments: A safe and adequate connection was made between the tow equipment and the bus.
Inspect tow equipment-wrecker interface.
Comments: A safe and adequate connection was made between the tow equipment and the wrecker.
Towing Comments: A front lift tow was performed incorporating a hydraulic under lift wrecker.
Description and location of any structural damage: No damage or deformation was observed.
General Comments: No problems were encountered with the tow or towing interface.

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 are replaced with deflated tire(s) of the appropriate type. A portable hydraulic floor jack is 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) are replaced with the original tire(s) and the hack is lowered. Any structural damage or permanent deformation is recorded on the test data sheet. This procedure is 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 3.2 inches to 10.8 inches. No deformation or damage was observed during testing. A complete listing of jacking point clearances is provided in the Jacking Test Data Form.

JACKING CLEARANCE SUMMARY

Condition	Frame Point Clearance
Front axle – one tire flat	6.3”
Rear axle – one tire flat	10.5”
Rear axle – two tires flat	8.6”

These test results were obtained prior to the accreditation of the lab on November 8, 2011; therefore, are not considered to be accredited in accordance with A2LA policy.

JACKING TEST DATA FORM

Bus Number: 1107	Date: 5-5-11
Personnel: E.D. & E.L.	Temperature (°F): 62

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

Deflated Tire	Jacking Pad Clearance Body/Frame (in)	Jacking Pad Clearance Axle/Suspension (in)	Comments
Right front	10.2 “ I 6.9 “ D	7.2 “ I 3.3 “ D	
Left front	10.0 “ I 6.3 “ D	6.5 “ I 3.2 “ D	
Right rear—outside	11.1 “ I 10.8 “ D	7.9 “ I 7.6 “ D	
Right rear—both	11.1 “ I 9.0 “ D	7.9 “ I 5.2 “ D	
Left rear—outside	10.8 “ I 10.5 “ D	8.1 “ I 7.7 “ D	
Left rear—both	10.8 “ I 8.6 “ D	8.1 “ I 5.3 “ D	
Additional comments of any deformation or difficulty during jacking:			
In order to achieve jacking from the front, ferry ride must be activated.			

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 is 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 will be checked for stability on the jack stands and for any damage to the jacking pads or bulkheads. The procedure is repeated for the rear end of the bus. The procedure is then repeated for the front and rear simultaneously.

5.6-III. DISCUSSION

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

The bus easily accommodated the placement of the vehicle lifts and jack stands and the procedure was performed without any instability noted.

These test results were obtained prior to the accreditation of the lab on November 8, 2011; therefore, are not considered to be accredited in accordance with A2LA policy.

HOISTING TEST DATA FORM

Bus Number: 1107	Date: 4-25-11
Personnel: T.S. & E.L.	Temperature (°F): 75

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 front and rear wheels are supported by the jack stands:
None noted.

5.7 STRUCTURAL DURABILITY TEST

5.7-I. TEST OBJECTIVE

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

5.7-II. TEST DESCRIPTION

The test vehicle is driven a total of 15,000 miles; approximately 12,500 miles on the PSBRTF Durability Test Track and approximately 2,500 miscellaneous other miles. The test will be conducted with the bus operated under three different loading conditions. The first segment will consist of approximately 6,250 miles with the bus operated at GVW. The second segment will consist of approximately 2,500 miles with the bus operated at SLW. The remainder of the test, approximately 6,250 miles, will be conducted with the bus loaded to CW. If GVW exceeds the axle design weights, then the load will be adjusted to the axle design weights and the change will be recorded. All subsystems are run during these tests in their normal operating modes. All recommended manufacturers servicing is to be followed and noted on the vehicle maintainability log. Servicing items accelerated by the durability tests will be compressed by 10:1; all others will be done on a 1:1 mi/mi basis. Unscheduled breakdowns and repairs are recorded on the same log as are any unusual occurrences as noted by the driver. Once a week the test vehicle shall be washed down and thoroughly inspected for any signs of failure.

5.7-III. DISCUSSION

The Structural Durability Test was started on June 13, 2011 and was conducted until February 17, 2012. The first 6,250 miles were performed at a GVW of 37,320 lbs. and completed on November 2, 2011. **Note: at GVL the load is 1,270 lbs over the front GAWR, 390 lbs over the rear GAWR and 1,660 lbs over the GVWR.** The next 2,500 mile SLW segment was performed at 33,320 lbs and completed on December 7, 2011 and the final 6,250 mile segment was performed at a CW of 27,680 lbs and completed on February 17, 2012.

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 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.

PROTERRA - TEST BUS #1107

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

DATE	TOTAL DURABILITY TRACK	TOTAL OTHER MILES	TOTAL
06/13/11 TO 06/19/11	187.00	10.00	197.00
06/20/11 TO 06/26/11	0.00	0.00	0.00
06/27/11 TO 07/03/11	305.00	15.00	320.00
07/4/11 TO 07/10/11	425.00	25.00	450.00
07/11 /11 TO 07/17/11	277.00	15.00	292.00
07/18 /11 TO 07/24/11	0.00	0.00	0.00
07/25 /11 TO 07/31/11	0.00	0.00	0.00
08/01/11 TO 08/07/11	0.00	0.00	0.00
08/08/11 TO 08/14/11	0.00	0.00	0.00
08/15/11 TO 08/21/11	0.00	0.00	0.00
08/22/11 TO 08/28/11	708.00	40.00	748.00
08/29/11 TO 09/04/11	152.00	8.00	160.00
09/5/11 TO 09/11/11	86.00	5.00	91.00
09/12/11 TO 09/18/11	831.00	43.00	874.00

PROTERRA - TEST BUS #1107

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

09/19/11 TO 09/25/11	485.00	27.00	512.00
09/26/11 TO 10/02/11	0.00	0.00	0.00
10/03/11 TO 10/09/11	723.00	40.00	763.00
10/10/11 TO 10/16/11	633.00	31.00	664.00
10/17/11 TO 10/23/11	165.00	10.00	175.00
10/24/11 TO 10/30/11	273.00	675.00	948.00
10/31/11 TO 11/06/11	261.00	172.00	433.00
11/7/11 TO 11/13/11	111.00	11.00	122.00
11/14/11 TO 11/20/11	323.00	15.00	338.00
11/21/11 TO 11/27/11	511.00	25.00	536.00
11/28/11 TO 12/04/11	384.00	28.00	412.00
12/5/11 TO 12/11/11	638.00	67.00	705.00
12/12/11 TO 12/18/11	449.00	82.00	531.00
12/19/11 TO 12/25/11	1.00	12.00	13.00
12/26/11 TO 01/01/12	0.00	0.00	0.00

PROTERRA - TEST BUS #1107

MILEAGE DRIVEN/RECORDED FROM DRIVER'S LOGS

1/2/12 TO 01/08/12	466.00	22.00	488.00
1/9/12 TO 01/15/12	1035.00	54.00	1089.00
1/17/12 TO 01/22/12	919.00	48.00	967.00
1/23/12 TO 01/29/12	707.00	37.00	744.00
01/30/12 TO 02/05/12	899.00	50.00	949.00
02/06/12 TO 02/12/12	434.00	22.00	456.00
02/13/12 TO 02/19/12	112.00	911.00	1023.00
TOTAL	12500.00	2500.00	15000.00

Table 4. Driving Schedule for Bus Operation on the Durability Test Track.

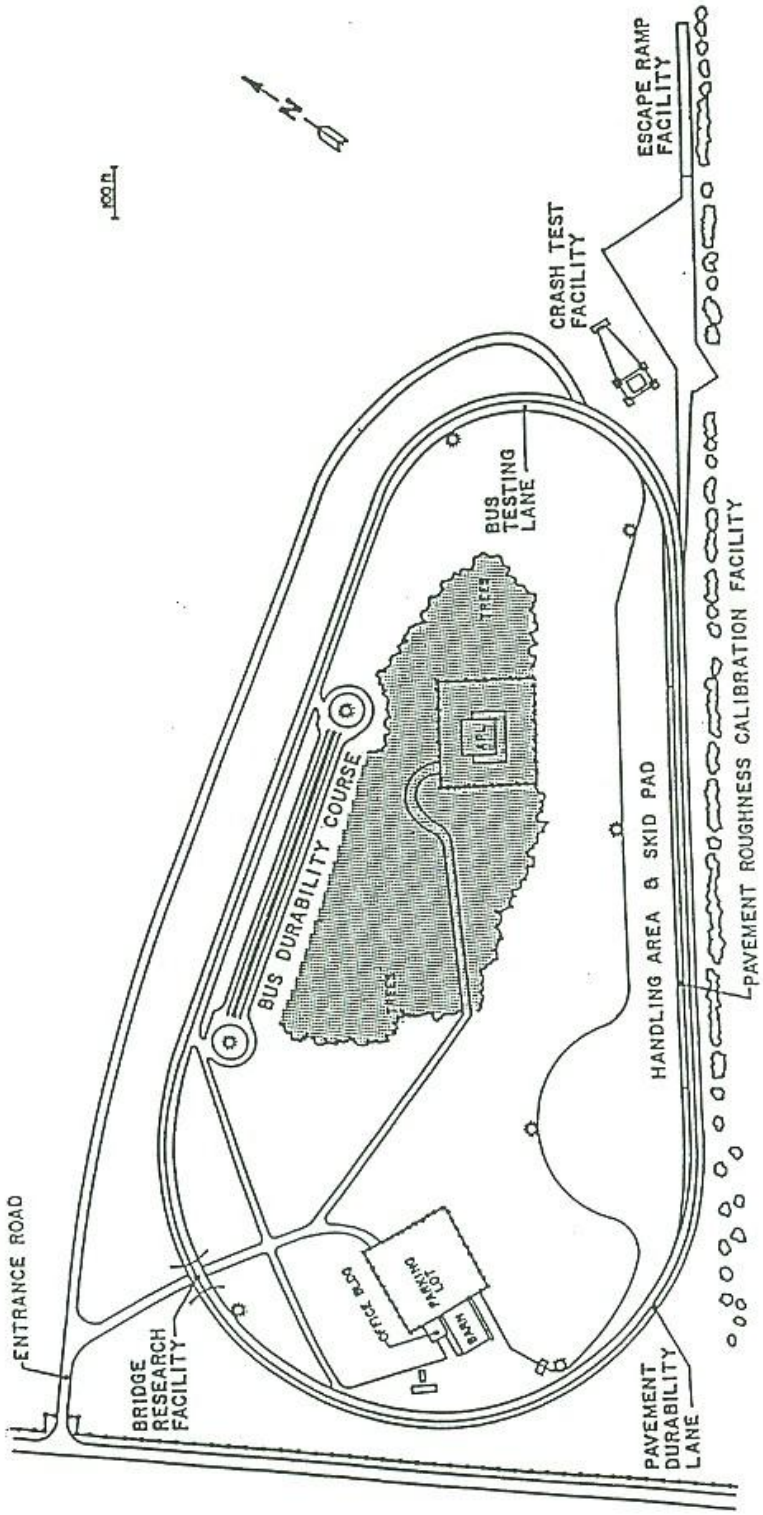
STANDARD OPERATING SCHEDULE

Monday through Friday

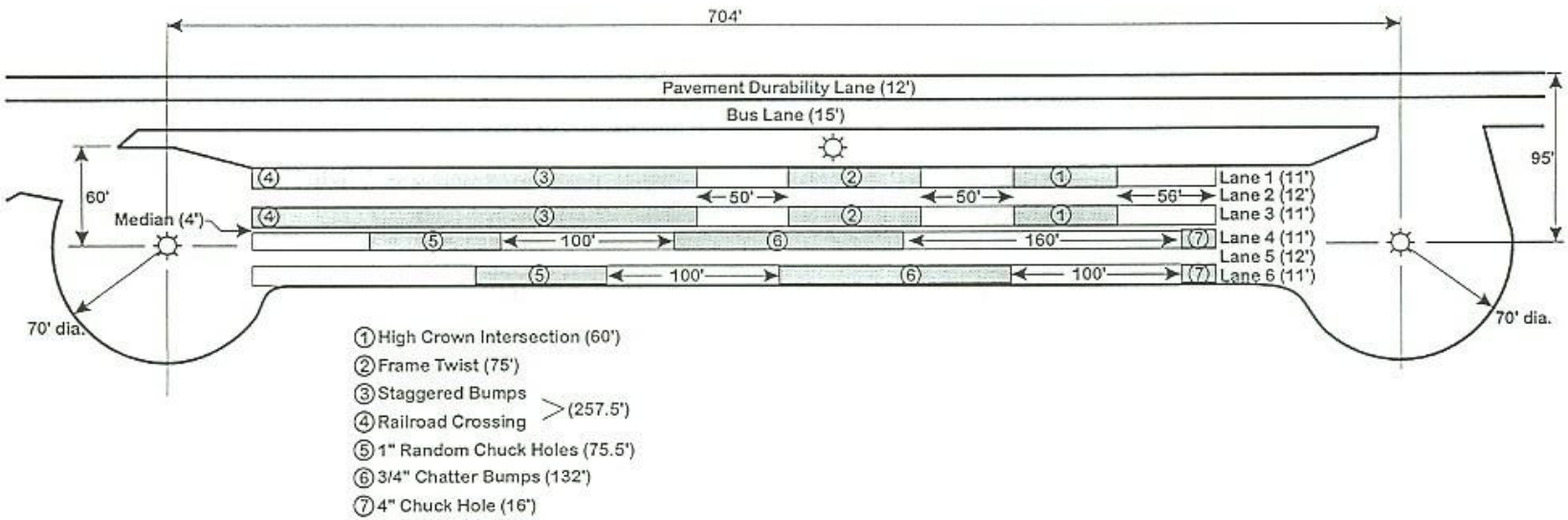
	HOUR	ACTION
Shift 1	midnight	D
	1:40 am	C
	1:50 am	B
	2:00 am	D
	3:35 am	C
	3:45 am	B
	4:05 am	D
	5:40 am	C
	5:50 am	B
	6:00 am	D
	7:40 am	C
	7:50 am	F
Shift 2	8:00 am	D
	9:40 am	C
	9:50 am	B
	10:00 am	D
	11:35 am	C
	11:45 am	B
	12:05 pm	D
	1:40 pm	C
	1:50 pm	B
	2:00 pm	D
	3:40 pm	C
	3:50 pm	F
Shift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

"PLAN VIEW OF PENN STATE BUS TESTING AND RESEARCH FACILITY"



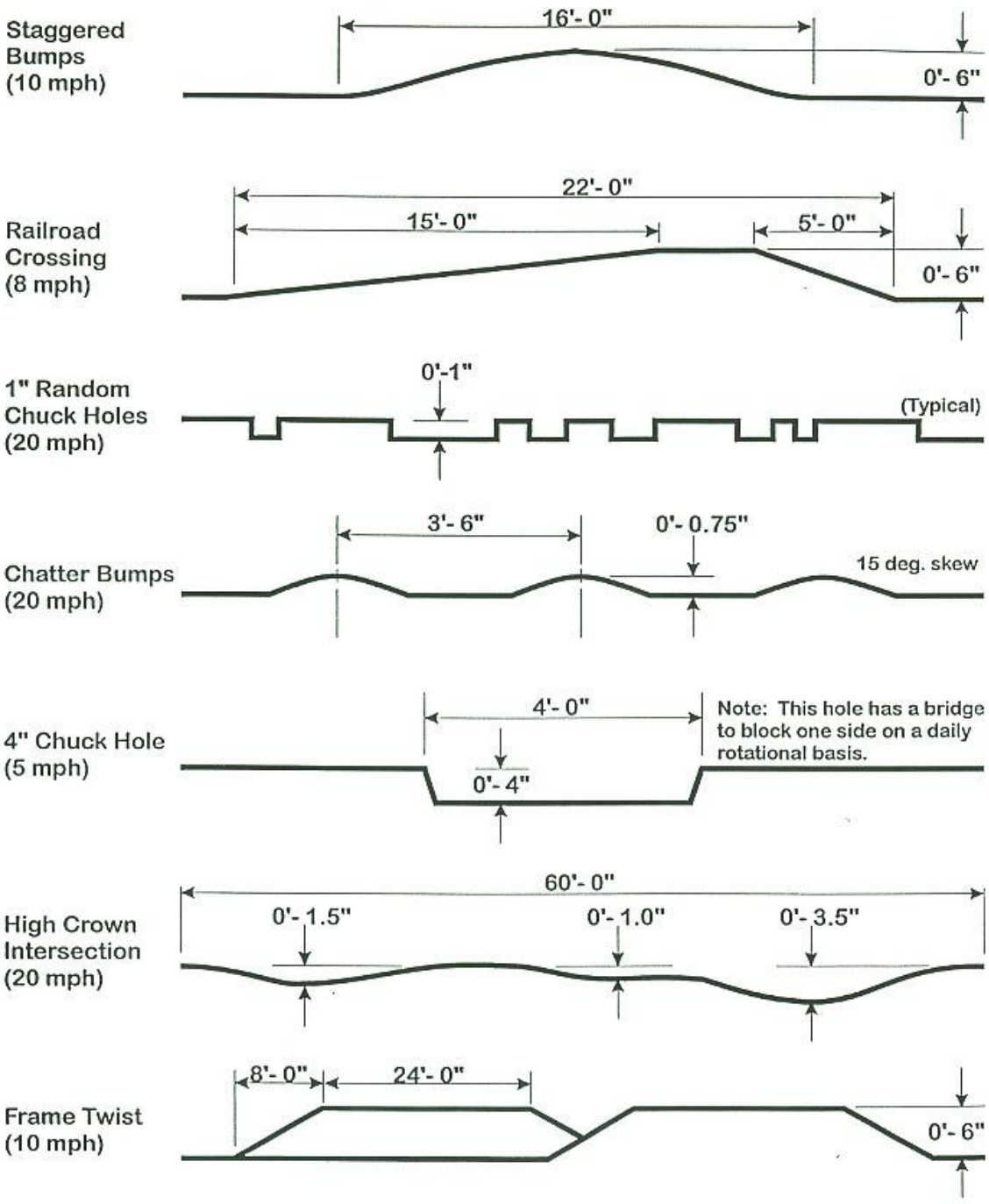
BUS TESTING AND RESEARCH TEST TRACK
UNIVERSITY PARK, PA



Plan View

Vehicle Durability Test Track

The Pennsylvania Transportation Institute
Penn State



Durability Element Profiles

The Pennsylvania Transportation Institute
Penn State

(Page 1 of 5)
UNSCHEDULED MAINTENANCE
Proterra #1107

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
06-14-11	16	The bus will not maintain proper ride height.	Manufacturer's representatives disabled all four height sensors and set the ride height with shop air until new leveling valves arrive.	4.00	10.00
06-23-11	197	The rear, upper radius rod mounts are broken.	Area prep and welded/repaired rear, upper radius rod mounts.	9.00	164.00
06-29-11	377	Three transmission mounting bolts are loose.	Manufacturer's representative tightened two bolts and drilled out/replaced one with a through bolt.	4.00	48.00
07-08-11	836	The transmission is leaking transmission fluid.	Troubleshooting performed by manufacturer's representatives for transmission fluid leak. Drain fluid being sent for analysis. Transmission topped with fluid.	8.00	8.00
08-29-11	2,007	Right side, first battery pack: five stainless steel nutsert spot welds have broken from the battery box.	Removed batteries. Rewelded/repaired nutserts. Reinstalled batteries.	2.00	16.00
09-01-11 and 09-02-11	2,167	The rear transmission mount is cracked and the mounting bolt is broken.	Removed broken bolt and cracked mount. Replaced new left side bolt and both left and right side mounts.	4.00	144.00
09-07-11	2,167	Manufacturer requests the transmission isolators be replaced.	Replaced transmission isolators.	2.00	16.00
09-09-11	2,219	Manufacturer troubleshooting "loss of throttle" condition.	Found damaged and broken wires on the transmission clutch speed sensor.	1.00	14.00

(Page 2 of 5)
UNSCHEDULED MAINTENANCE
Proterra #1107

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
09-09-11	2,219	The windshield wipers are inoperative. Wiper motor failed.	Found damaged and broken wires on the transmission clutch speed sensor. Replaced transmission clutch speed sensor.	1.00	14.00
09-12-11	2,258	Two pins on the Deutsch connector for the DC to DC converter are damaged.	Manufacturer repaired/replaced two pins.	1.00	22.00
09-19-11	3,141	The brass air fitting is broken from the top plate of the right front air bag.	Replaced brass fitting.	2.00	5.00
09-19-11	3,141	The heads of three transmission case bolts are broken off.	Manufacturer representative replaced three transmission case bolts.	2.00	5.00
09-20-11	3,407	Received the replacement wiper motor that was ordered on 09/09/11.	Replaced wiper motor.	2.00	2.00
09-26-11	3,644	The electrical system is showing erratic voltage readings.	Manufacturer removed the right side battery pack and replaced the battery module. Battery pack reinstalled.	1.00	4.00
09-27-11	3,644	The left front transmission cross member bushing has failed.	Manufacturer representative replaced the left front transmission cross member bushing.	3.00	48.00
10-05-11	3,989	The adhesive failed between the glass and the aluminum frame of the 5th passenger window, left side.	Reinstalled window.	3.00	1.50

UNSCHEDULED MAINTENANCE

Proterra #1107

DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
10-05-11	3,989	The destination sign is loose.	Found broken brackets for destination sign. Removed sign for repairs.	.50	.50
10-06-11	4,135	Manufacturer requests rear transmission single mount be replaced with duel mount.	Removed transmission/power train cradle. Removed single mount. Installed Duel mount. Reinstalled transmission/power train.	15.00	16.00
10-06-11	4,135	The left front tire is worn.	Replaced left front tire.	3.00	1.00
10-12-11	4,916	The left front tire is flat.	Replaced left front tire.	2.00	1.00
10-13-11	5,064	The windshield wiper motor failed.	Manufacturer representative replaced the windshield wiper motor.	1.00	1.00
10-14-11	5,071	Manufacturer is finding false fault codes in transmission ECU.	Manufacturer representative added a Gateway module to the rear interior fuse panel for the transmission ECU.	1.00	1.00
10-17-11	5,071	The bottom right transmission mounting bolt is broken.	Manufacturer representative replaced mounting bolt.	2.00	2.00
10-17-11	5,071	The transmission will intermittently not shift properly.	Manufacturer representative trouble shooting electrical system and CAN system. Manufacturer added a Gateway module to the transmission CAN system.	4.00	55.00

UNSCHEDULED MAINTENANCE

Proterra #1107

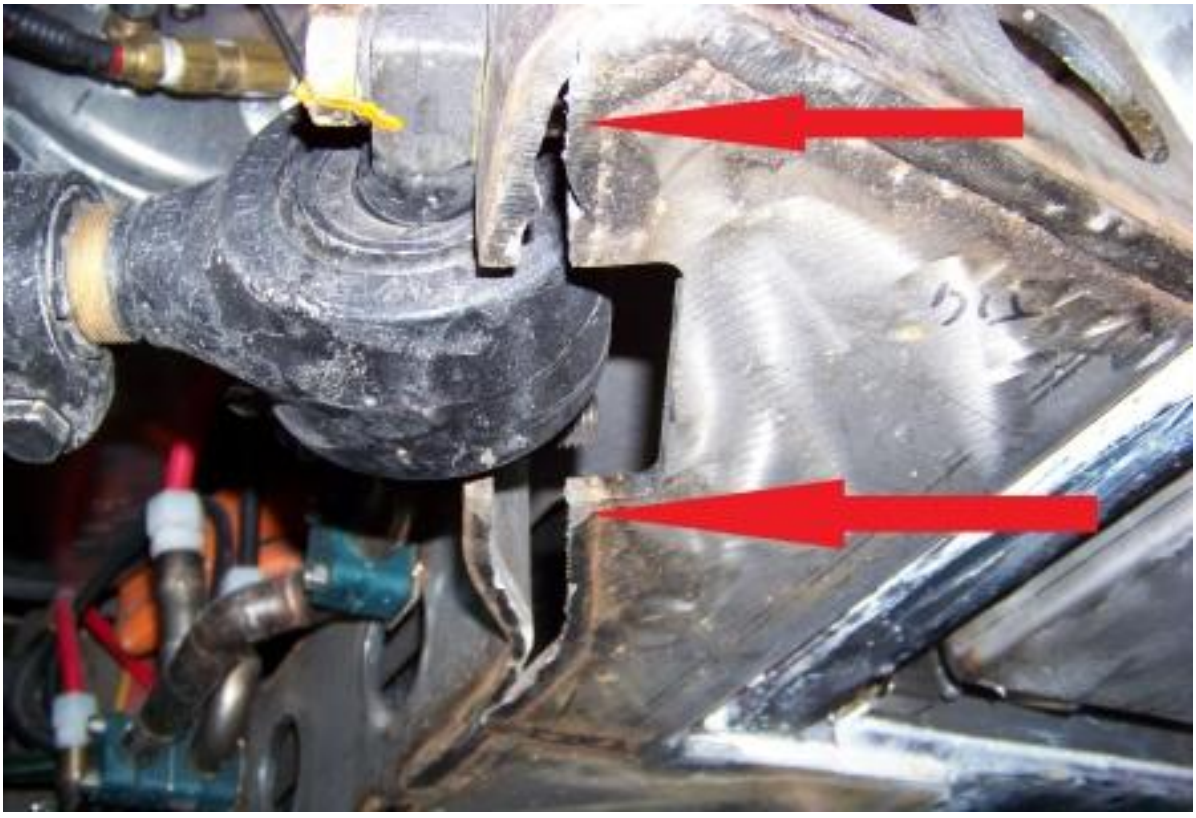
DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
10-26-11	5,824	The front tires continue to wear excessively.	Manufacturer representative requests shims to be added to the front suspension. Replaced front shocks.	8.00	8.00
10-28-11	6,019	Bus experiencing loss and power and loss of throttle.	Replaced failed traction motor resistor.	2.00	6.00
11-01-11	6,202	Manufacturer requests new design transmission cradle be installed.	Manufacturer representative removed transmission cradle and installed new design cradle.	6.00	48.00
11-02-11	6,202	Two body-to-frame mounting brackets are cracked/broken. One right side forward of front axle the other left side behind the front axle.	Repaired/welded both body to frame mounts	4.00	2.00
11-08-11	6,669	The safety latch on the 6th passenger window, left side is broken.	Replaced 6th passenger window, left side.	2.00	2.00
01-03-12	9,284	The transmission is leaking transmission fluid at the input seal. The case bolts are stripped. There is no hydraulic pressure and the speed switch is malfunctioning.	Manufacturer representative replaced the transmission.	18.00	288.00
01-12-12	10,554	The steering column support is broken at the weld on the right side diagonal support.	Installed angel steel to support.	1.00	4.00
01-13-12	10,765	The right rear, lower radius rod inboard bolt on the axle is broken. The outboard bolt is stripped and the threads are damaged in the axle.	Removed broken bolt. Drilled out outboard hole and tapped to ¾ - 10. Installed new bolts.	6.00	6.00

UNSCHEDULED MAINTENANCE
Proterra #1107

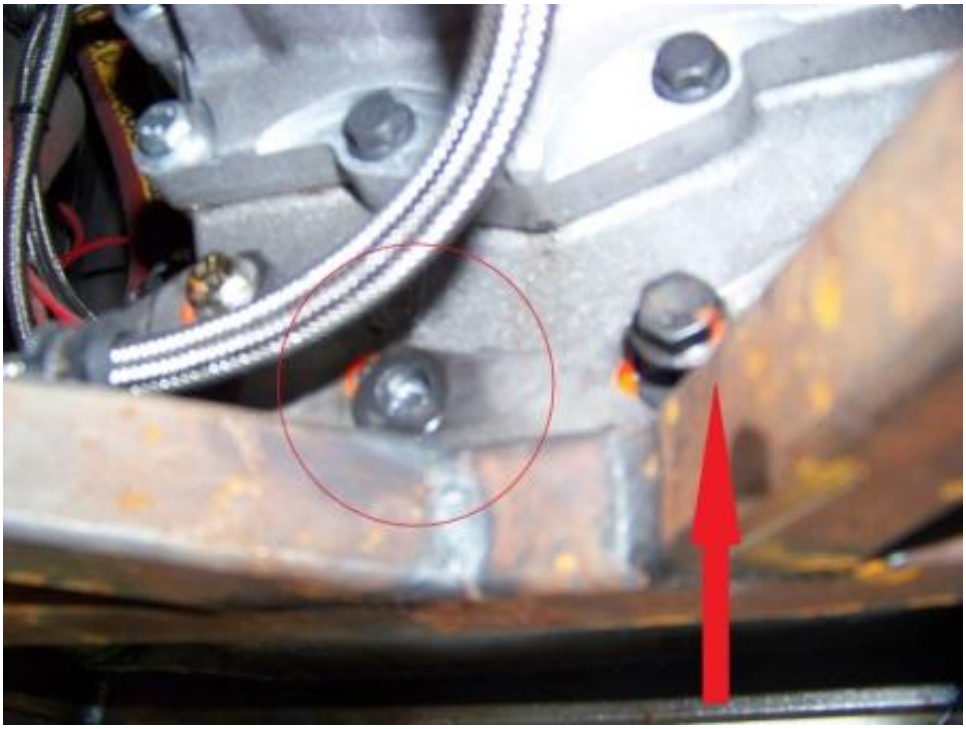
DATE	TEST MILES	SERVICE	ACTIVITY	MAN HOURS	DOWN TIME
01-24-12	12,018	Troubleshooting for intermittent loss of power steering and all electrical power.	Manufacturer representative found multiple wires damaged/shorted at the ZR/MUX station at the left front wheel well. Repaired all damaged wires. Manufacturer also installed a fluid temperature sensor in the transmission.	8.00	8.00
02-01-12	12,910	The transmission oil pump is inoperative.	Located and repaired broken wire in the transmission connector.	2.00	2.00
02-06-12	13,604	The left side forward battery pack is not accepting charge.	Manufacturer representative removed battery pack. Found moisture build up on circuit board. Circuit board dried. One battery module replaced due to corrosion. Battery pack reinstalled.	6.00	6.00
02-08-12	13,855	Test bus experiencing intermittent loss of acceleration.	Manufacturer representative trouble shooting communication between drive train and acceleration pedal. No diagnosis at this time.	18.00	23.00
02-10-12	13,977	The output shaft in the transmission is broken.	Removed transmission and separated drive motor.	12.00	4.00
02-13-12	13,977	Replacement transmission arrived.	Manufacturer representative installed new drive motor/transmission assembly.	28.50	72.00
02-23-12	15,000	Loss of throttle and "Hot Transmission" warning light is on. The electric drive motor failed.	Manufacturer replaced the electric drive motor.	6.00	24.00

UNSCHEDULED MAINTENANCE

BROKEN REAR UPPER RADIUS ROD MOUNT
(197 TEST MILES)



UNSCHEDULED MAINTENANCE CONT.

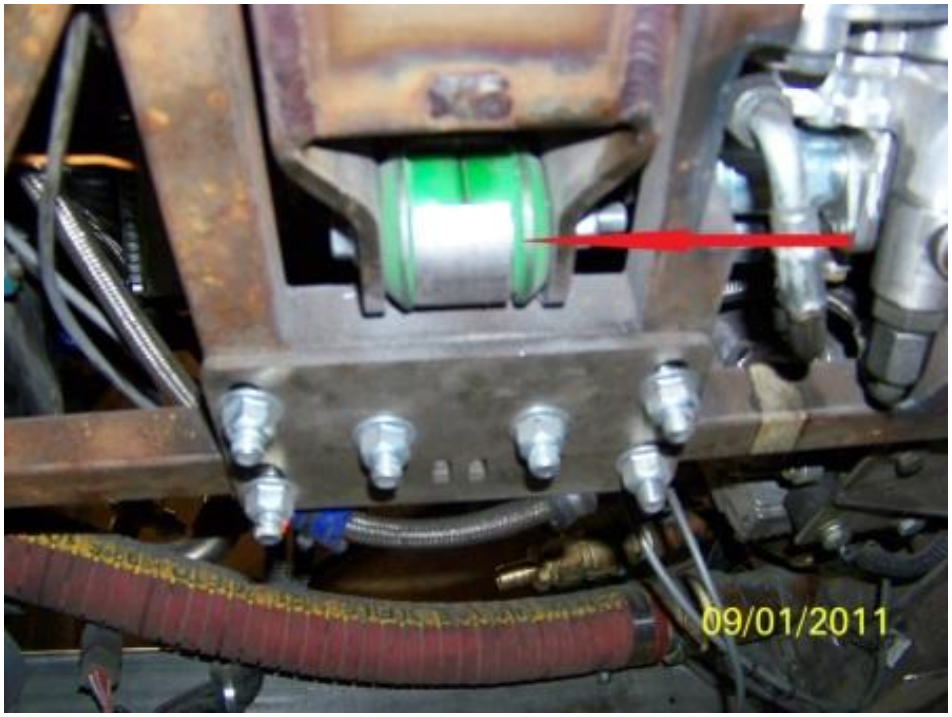


BROKEN AND LOOSE TRANSMISSION MOUNTING BOLTS
(377 TEST MILES)

5 BROKEN NUTSERTS IN FIRST
RIGHT SIDE BATTERY PACK
(2,007 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.

BROKEN TRANSMISSION MOUNTING BOLT (2,167 TEST MILES)



BROKEN REAR TRANSMISSION MOUNT (2,167 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.

DAMAGED TRANSMISSION CLUTCH SPEED SENSOR (2,219 TEST MILES)

BROKEN BRASS AIR FITTING ON RIGHT FRONT AIR BAG (3,141 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.

THREE BROKEN TRANSMISSION CASE BOLTS
(3,141 TEST MILES)

FAILED BATTERY PACK
(3,644 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.

FAILED LEFT FRONT TRANSMISSION CROSSMEMBER BUSHING (3,644 TEST MILES)

ADHESIVE FAILURE AT 5TH PASSENGER WINDOW, LEFT SIDE (3,989 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.

NEW DUEL MOUNT FOR TRANSMISSION
(4,135 TEST MILES)

GATEWAY MODULE ADDED TO
TRANSMISSION "CAN" SYSTEM
(5,071 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.

FAILED TRACTION MOTOR RESISTOR
(6,019 TEST MILES)

NEW DESIGN TRANSMISSION CRADLE
(6,202 TEST MILES)

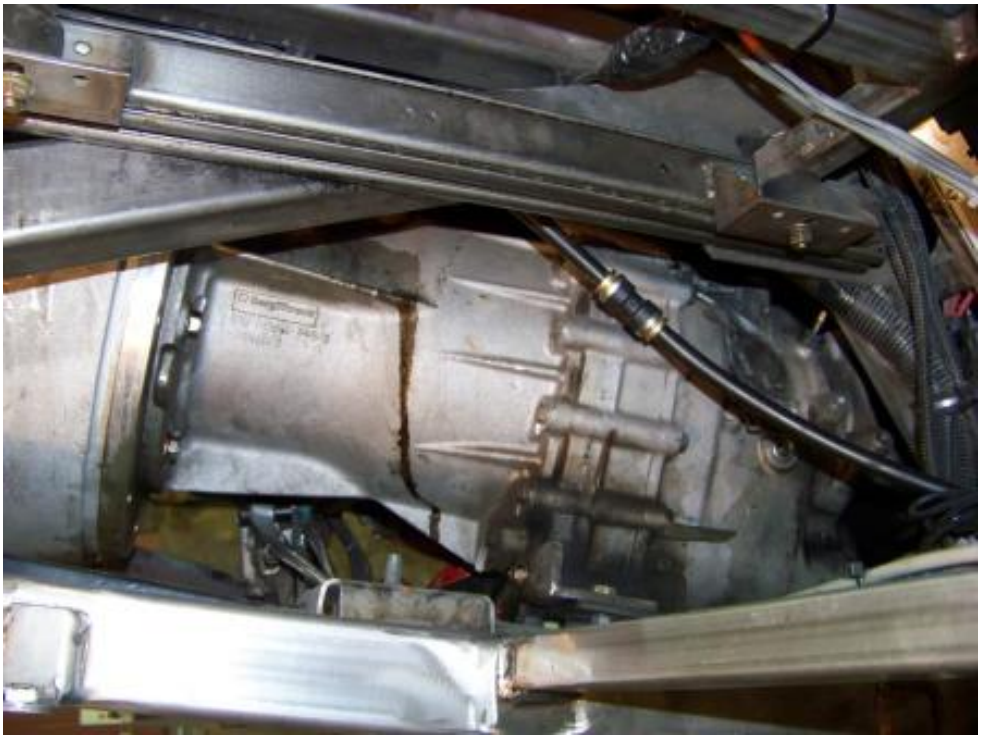
UNSCHEDULED MAINTENANCE CONT.

FAILED BODY/FRAME MOUNTING BRACKET RIGHT SIDE, FORWARD OF FRONT AXLE (6,202 TEST MILES)

FAILED BODY/FRAME MOUNTING BRACKET LEFT SIDE REAR OF FRONT AXLE (6,202 TEST MILES)

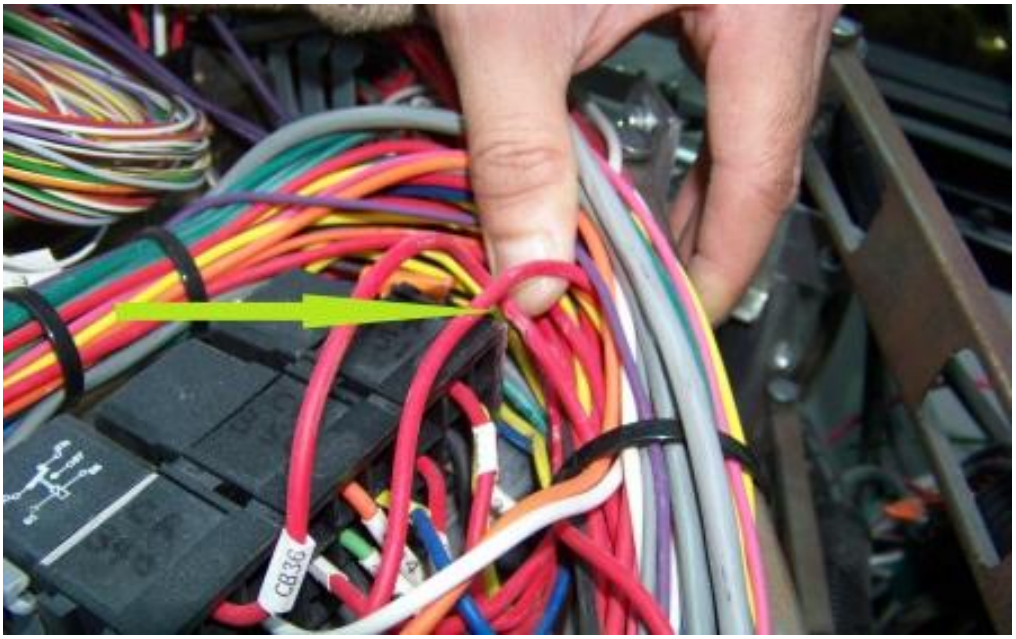
UNSCHEDULED MAINTENANCE CONT.

FAILED SAFTEY LATCH, 6TH WINDOW, LEFT SIDE
(6,669 TEST MILES)



FAILED TRANSMISSION REPLACED
(9,284 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.



DAMAGED WIRES AT ZR/MUX CONTROL
(12,018 TEST MILES)

MOISTURE FOUND IN BATTERY PACK CIRCUIT BOARD
(13,604 TEST MILES)

UNSCHEDULED MAINTENANCE CONT.

BROKEN TRANSMISSION OUTPUT SHAFT
(13,977 TEST MILES)

FAILED ELECTRIC DRIVE MOTOR
(15,000 TEST MILES)

6. ENERGY ECONOMY/RANGE TEST USING AN APPROPRIATE OPERATING CYCLE

6-I. TEST OBJECTIVE

The objective of this test is to provide accurate comparable electric energy consumption and range data for battery-electric transit buses. This energy economy test bears no relation to the calculations done by the Environmental Protection Agency (EPA) to determine levels for the Corporate Average Fuel Economy Program. EPA's calculations are based on tests conducted under laboratory conditions intended to simulate city and highway driving.

Energy consumed by battery-electric vehicles and overall efficiency depends on a variety of factors. Driving cycle, driving time, vehicle configuration, temperature, regenerative braking, and power management strategy heavily influence vehicle range. Efficiency is affected by the state-of-charge (SOC) of the battery, which changes continuously during the test. Battery type and recharging process used are also important. All of the above factors complicate efforts to develop a standardized test. In spite of these influences and the many different vehicle types and configurations, two important operational considerations are common to all battery-electric buses: vehicle range and total energy consumed.

The Energy Economy/Range Test, as designated here, is a measurement of the total stored electrical energy expended by a bus traveling a specified test loop under specified operating conditions to the limit of its useful range. The results of the test may not represent actual mileage but will provide objective data that can be used to compare buses tested under this procedure.

6-II. TEST DESCRIPTION

The Energy Economy/Range Test will be performed as soon as possible (weather permitting) after the completion of the GVW portion of the structural durability test. It will be conducted on the bus test lane at the PTI test track. This test requires operation of the bus over a course based on a modified Transit Coach Operating Duty Cycle (ADB Cycle). Signs are erected at measured points to delineate the test course.

The operating profile for testing purposes shall consist of simulated transit type service at seated load weight. The three test phases (figure 6-1) are: a central business district (CBD) phase of approximately 2 miles with 7 stops per mile and a top speed of 20 mph; an arterial phase of approximately 2 miles with 2 stops per mile and a top speed of 40 mph; and a commuter phase of approximately 4 miles with 1 stop and a maximum speed of 40 mph. If the maximum vehicle speed is less than 40 mph, the test will be performed at the governed speed and will be so noted on the Energy Economy/Range Data Form. The test will begin with the batteries at a full state of charge and the pack within the manufacturer-designated operating temperature range. At each designated stop the bus will remain stationary for seven seconds. During this time, the passenger doors shall be opened and closed.

The ADB cycle is structured as a set number of miles in a fixed time in the following order: CBD, Arterial, CBD, Arterial, CBD, and Commuter. A test run will comprise 3 Central Business District (CBD) phases, 2 Arterial phases, and 1 Commuter phase. Test runs will be repeated traveling in both the clockwise and counter-clockwise directions until bus operation is limited by range, i.e. the bus is no longer able to maintain the specified speed.

The test will be initiated with the battery pack at a full SOC. After each phase, the battery voltage and temperature will be reported. The test will continue with the bus completing runs in both directions until the vehicle can no longer maintain the specified test speed. Total miles traveled (range), pertinent environmental data, and the total energy consumed will be reported.

FUEL ECONOMY PRE-TEST MAINTENANCE FORM

Bus Number: 1107	Date: 2-21-12	SLW (lbs): 33,320
Personnel: B.L., P.D., T.S. & J.P.		

FUEL SYSTEM	OK	Date	Initials
Install fuel measurement system	N/A	2/21/12	B.L.
Replace fuel filter	N/A	2/21/12	B.L.
Check for fuel leaks	N/A	2/21/12	B.L.
Specify fuel type (refer to fuel analysis)	Electric		
Remarks: None noted.			
BRAKES/TIRES	OK	Date	Initials
Inspect hoses	✓	2/21/12	B.L.
Inspect brakes	✓	2/21/12	B.L.
Relube wheel bearings	✓	2/21/12	B.L.
Check tire inflation pressures (mfg. specs.)	✓	2/21/12	B.L.
Remarks: None noted.			
COOLING SYSTEM	OK	Date	Initials
Check hoses and connections	✓	2/21/12	B.L.
Check system for coolant leaks	✓	2/21/12	B.L.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 2)

Bus Number: 1107	Date: 2-21-12
Personnel: B.L., P.D. T.S. & J.P.	

ELECTRICAL SYSTEMS	OK	Date	Initials
Check battery	✓	2/21/12	B.L.
Inspect wiring	✓	2/21/12	B.L.
Inspect terminals	✓	2/21/12	B.L.
Check lighting	✓	2/21/12	B.L.
Remarks: None noted.			

DRIVE SYSTEM	OK	Date	Initials
Drain transmission fluid	✓	2/21/12	B.L.
Replace filter/gasket	✓	2/21/12	B.L.
Check hoses and connections	✓	2/21/12	B.L.
Replace transmission fluid	✓	2/21/12	B.L.
Check for fluid leaks	✓	2/21/12	B.L.
Remarks: None noted.			

LUBRICATION	OK	Date	Initials
Drain crankcase oil	✓	2/21/12	B.L.
Replace filters	✓	2/21/12	B.L.
Replace crankcase oil	✓	2/21/12	B.L.
Check for oil leaks	✓	2/21/12	B.L.
Check oil level	✓	2/21/12	B.L.
Lube all chassis grease fittings	✓	2/21/12	B.L.
Lube universal joints	✓	2/21/12	B.L.
Replace differential lube including axles	✓	2/21/12	B.L.
Remarks: None noted.			

FUEL ECONOMY PRE-TEST MAINTENANCE FORM (page 3)

Bus Number: 1107	Date: 2-21-12
Personnel: B.L., P.D., T.S. & J.P.	

EXHAUST/EMISSION SYSTEM	OK	Date	Initials
Check for exhaust leaks	N/A	2/21/12	B.L.
Remarks: None noted.			

ENGINE	OK	Date	Initials
Replace air filter	N/A	2/21/12	B.L.
Inspect air compressor and air system	✓	2/21/12	B.L.
Inspect vacuum system, if applicable	✓	2/21/12	B.L.
Check and adjust all drive belts	N/A	2/21/12	B.L.
Check cold start assist, if applicable	N/A	2/21/12	B.L.
Remarks: None noted.			

STEERING SYSTEM	OK	Date	Initials
Check power steering hoses and connectors	✓	2/21/12	B.L.
Service fluid level	✓	2/21/12	B.L.
Check power steering operation	✓	2/21/12	B.L.
Remarks: None noted.			

	OK	Date	Initials
Ballast bus to seated load weight	✓	2/21/12	B.L.

TEST DRIVE	OK	Date	Initials
Check brake operation	✓	2/21/12	B.L.
Check transmission operation	✓	2/21/12	B.L.
Remarks: None noted.			

FUEL ECONOMY DATA FORM (ELECTRIC VEHICLE)
Page 1 of 2

Bus Number:	1107-12
Date:	2/23/2012
Manufacturer:	Proterra
Personnel:	Timothy Cleary (Engineer), Rick (LTI Driver) as well as Michael Walker and Christian from Proterra
Temperature (F):	50.00
Wind Speed/Direction:	12 MPH (W)
Humidity (%):	32.00
Barometric Pressure :	29.62

Run Number:	1
Test Direction:	Counter Clockwise

CAN Recorded/Corrected Data

	Time [sec]		Battery Level [kWh]		Battery Temperature [Celsius]	Energy Used [kWh]
Cycle Type	Start	End	Start	End	End	
CBD #1	0	597.2	0	-3.3	22	-3.3
ART #1	597.2	912.3	-3.3	-7.41	23	-4.11
CBD #2	912.3	1494	-7.41	-10.71	23	-3.3
ART #2	1494	1791	-10.71	-14.7	24	-3.99
CBD #3	1791	2367	-14.7	-18.07	24	-3.37
Commuter	2367	2791	-18.07	-23.46	25	-5.39
CBD #1	2791	3370	-23.46	-26.81	25	-3.35
ART #1	3370	3662	-26.81	-30.87	25	-4.06
CBD #2	3662	4220	-30.87	-34.16	26	-3.29
ART #2	4220	4501	-34.16	-38.14	27	-3.98
CBD #3	4501	5060	-38.14	-41.43	27	-3.29
Commuter	5060	5446	-41.43	-46.56	27	-5.13
CBD #1	5446	5997	-46.56	-49.73	28	-3.17
ART #1	5997	6290	-49.73	-53.32	28	-3.59
CBD #2	6290	6843	-53.32	-56.46	28	-3.14
Charge Data	6932	9456	-56.49	5.48	29	61.97

Average Energy Use [kWh]	
CBD	-3.28
ART	-3.95
Commuter	-5.26

* Data recorded such as SOC are read directly from the Proterra CAN bus. SOC is not verified--simply recorded. Energy calculations use calibrated current readings only, no SOC values are used in energy consumption calculations

A negative energy indicates a discharge of the system or energy out of the battery

FUEL ECONOMY DATA FORM (ELECTRIC VEHICLE)

Page 1 of 2

Bus Number:	1107-12
Date:	2/23/2012
Manufacturer:	Proterra
Personnel:	Timothy Cleary (Engineer), Rick (LTI Driver) as well as Michael Walker and Christian form Proterra
Temperature (F):	50.00
Wind Speed/Direction:	12 MPH (W)
Humidity (%):	32.00
Barometric Pressure :	29.62

Run Number:	2
Test Direction:	Clockwise

CAN Recorded Data

	Time		Battery Level [kWh]		Battery Temperature [Celsius]	Energy Used [kWh]
Cycle Type	Start	End	Start	End	End	
CBD #1	0	573.4	0	-3.2	28	-3.2
ART #1	573.4	866.7	-3.2	-7.19	28	-3.99
CBD #2	866.7	1433	-7.19	-10.44	28	-3.25
ART #2	1433	1712	-10.44	-14.28	29	-3.84
CBD #3	1712	2275	-14.28	-17.55	29	-3.27
Commuter	2275	2670	-17.55	-22.75	29	-5.2
CBD #1	2670	3226	-22.75	-25.89	29	-3.14
ART #1	3226	3521	-25.89	-29.89	30	-4
CBD #2	3521	4089	-29.89	-33.06	30	-3.17
ART #2	4089	4381	-33.06	-37.15	31	-4.09
CBD #3	4381	4935	-37.15	-40.48	31	-3.33
Commuter	4935	5313	-40.48	-45.89	31	-5.41
CBD #1	5313	5868	-45.89	-49.02	31	-3.13
ART #1	5868	6170	-49.02	-52.86	32	-3.84
CBD #2	6170	6731	-52.86	-56.06	31	-3.2
Charge Data	6731	8489	-56.06	4.49	33	60.55

	Average Energy Use [kWh]
CBD	-3.21
ART	-3.95
Commuter	-5.305

FUEL ECONOMY DATA FORM (ELECTRIC VEHICLE)
Page 2 of 2

* Data recorded such as SOC are read directly from the Proterra CAN bus. SOC is not verified--simply recorded. Energy calculations use calibrated current readings only, no SOC values are used in energy consumption calculations

A negative energy indicates a discharge of the system or energy out of the battery

Energy Economy Summary Sheet

Bus Manufacture	: Proterra	Temperature (F)	: 50
Bus Model	: Electric	Wind Speed/Direction	: 12 MPH (W)
Bus Number	: 1107-12	Humidity (%)	: 32
Test Date	: 2/23/12	Barometric Pressure	: 29.62
Fuel Type	: Electric		

Run # 1 CCW

Cycle	Average Phase Energy Used [kWh]	Phase Distance [Miles]	Total Distance Traveled [Miles]	Fuel Economy [kWh/Mile]	* Fuel Economy [MPG] Diesel Equivalent
CBD	3.28	1.91	15.28	1.72	21.94
ART	3.95	1.91	9.55	2.07	18.22
COM	5.26	3.82	7.64	1.38	27.33

Run # 2 CW

Cycle	Average Phase Energy Used [kWh]	Phase Distance [Miles]	Total Distance Traveled [Miles]	Fuel Economy [kWh/Mile]	* Fuel Economy [MPG] Diesel Equivalent
CBD	3.21	1.91	15.28	1.68	22.38
ART	3.95	1.91	9.55	2.07	18.19
COM	5.31	3.82	7.64	1.39	27.10

Run Consistency: % difference from overall average of total electrical energy used

Total Energy Use Run # 1 [kWh]	56.46
Total Energy Use Run # 2 [kWh]	56.06
Average Electrical Energy Used [kWh] :	56.2600
Run # 1 Consistency[%] :	0.355
Run # 2 Consistency[%] :	-0.355

Summary	Fuel Economy [kWh/Mile]	* Fuel Economy [MPG] Diesel Equivalent
Average CBD Phase Consumption	1.70	22.16
Average Arterial Phase Consumption	2.07	18.20
Average Commuter Phase Consumption	1.38	27.21
Overall Average Consumption	1.73	21.72

* Using EPA and US DoE data a simplified conversion to MPGe is performed.

$FE_{MPGe} = (E_D \times 100) / FC_{EV}$

where:

FE_{MPGe} = Fuel Economy in miles per gallon diesel equivalent

FC_{EV} = Measured unadjusted electrical consumption [kWh/100Mile]

E_D= Energy content per gallon of diesel = 128,450 BTU/gallon = 37.64 kWh/gallon

[US DoE, Alternative Fuels & Advanced Vehicles Data Center]

7. NOISE

7.1 INTERIOR NOISE AND VIBRATION TESTS

7.1-I. TEST OBJECTIVE

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

7.1-II. TEST DESCRIPTION

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

1. With the bus stationary, a white noise generating system shall provide a uniform sound pressure level equal to 80 dB(A) on the left, exterior side of the bus. The engine and all accessories will be switched off and all openings including doors and windows will be closed. This test will be performed at the ABTC.

2. The bus accelerating at full throttle from a standing start to 35 mph on a level pavement. All openings will be closed and all accessories will be operating during the test. This test will be performed on the track at the Test Track Facility.

3. The bus will be operated at various speeds from 0 to 55 mph with and without the air conditioning and accessories on. Any audible vibration or rattles will be noted. This test will be performed on the test segment between the Test Track and the Bus Testing Center.

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

7.1-III. DISCUSSION

This test is performed in three parts. The first part exposes the exterior of the vehicle to 80.0 dB(A) on the left side of the bus and the noise transmitted to the interior is measured. The overall average of the six measurements was 51.5 dB(A); ranging from 50.7 dB(A) at the rear passenger seats to 52.6 dB(A) at the front passenger seats. The interior ambient noise level for this test was < 34.0 dB(A).

The second test measures interior noise during acceleration from 0 to 35 mph. This noise level ranged from 71.9 dB(A) at the front passenger seats to 72.9 dB(A) at the driver's seat. The overall average was 72.4 dB(A). The interior ambient noise level for this test was 22.6 dB(A).

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

These test results were obtained prior to the accreditation of the lab on November 8, 2011; therefore, are not considered to be accredited in accordance with A2LA policy.

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

Bus Number: 1107	Date: 4-26-11
Personnel: T.S. & E.L.	
Temperature (°F): 77	Humidity (%): 52
Wind Speed (mph): 10	Wind Direction: SW
Barometric Pressure (in.Hg): 29.90	
Initial Sound Level Meter Calibration: ■ checked by: T.S.	
Interior Ambient Noise Level dB(A): < 34.0	Exterior Ambient Noise Level dB(A): 49.6
Microphone Height During Testing (in): 29.0 (from seat cushion)	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	51.6
Front Passenger Seats	52.6
In Line with Front Speaker	52.5
In Line with Middle Speaker	50.8
In Line with Rear Speaker	50.8
Rear Passenger Seats	50.7

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

Comments: All readings taken in the center aisle.

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

Bus Number: 1107	Date: 12/13/11
Personnel: J.S., T.S., B.L. & S.C.	
Temperature (°F): 42	Humidity (%): 41
Wind Speed (mph): Calm	Wind Direction: Calm
Barometric Pressure (in.Hg): 30.40	
Initial Sound Level Meter Calibration: ■ checked by: S.C.	
Interior Ambient Noise Level dB(A): 22.6	Exterior Ambient Noise Level dB(A): 32.5
Microphone Height During Testing (in): 48	

Measurement Location	Measured Sound Level dB(A)
Driver's Seat	72.9
Front Passenger Seats	71.9
Middle Passenger Seats	72.6
Rear Passenger Seats	72.0

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

Comments: All readings taken in the center aisle.

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

Bus Number: 1107	Date: 12/13/11
Personnel: J.S., T.S., B.L. & S.C.	
Temperature (°F): 42	Humidity (%): 41
Wind Speed (mph): Calm	Wind Direction: Calm
Barometric Pressure (in.Hg): 30.40	

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

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

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

7.1 INTERIOR NOISE TEST

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

7.2 EXTERIOR NOISE TESTS

7.2-I. TEST OBJECTIVE

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

7.2-II. TEST DESCRIPTION

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

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

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

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

During the test, special attention should be paid to:

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

7.2-III. DISCUSSION

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

With an exterior ambient noise level of 34.4 dB(A), the average test result obtained while accelerating from a constant speed was 60.0 dB(A) on the right side and 59.8 dB(A) on the left side.

When accelerating from a standstill with an exterior ambient noise level of 33.7 dB(A), the average of the results obtained were 56.8 dB(A) on the right side and 57.4 dB(A) on the left side.

With the vehicle stationary and the engine, accessories, and air conditioning on, the measurements averaged 42.9 dB(A) at idle. With the accessories and air conditioning off, the readings averaged the same 42.9 dB(A) at idle. The exterior ambient noise level measured during this test was 34.5 dB(A). The test bus is an electric vehicle, therefore there is only one state of idle.

EXTERIOR NOISE TEST DATA FORM
Accelerating from Constant Speed

Bus Number: 1107	Date: 12/13/11
Personnel: J.S., S.C., T.S. & B.L.	
Temperature (°F): 42	Humidity (%): 41
Wind Speed (mph): Calm	Wind Direction: Calm
Barometric Pressure (in.Hg): 30.40	
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: S.C.	
Initial Sound Level Meter Calibration: ■ checked by: S.C.	
Exterior Ambient Noise Level dB(A): 34.4	

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	60.0	1	59.7
2	59.9	2	59.2
3	59.2	3	58.4
4	59.5	4	57.8
5	59.1	5	59.8
Average of two highest actual noise levels = 60.0 dB(A)		Average of two highest actual noise levels = 59.8 dB(A)	

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

EXTERIOR NOISE TEST DATA FORM
Accelerating from Standstill

Bus Number: 1107	Date: 12-13-11
Personnel: J.S., S.C., T.S. & B.L.	
Temperature (°F): 42	Humidity (%): 41
Wind Speed (mph): Calm	Wind Direction: Calm
Barometric Pressure (in.Hg): 30.40	
Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: S.C.	
Initial Sound Level Meter Calibration: ■ checked by: S.C.	
Exterior Ambient Noise Level dB(A): 33.7	

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	56.8	1	56.8
2	56.7	2	57.1
3	55.9	3	56.8
4	55.9	4	57.6
5	56.1	5	56.7
Average of two highest actual noise levels = 56.8 dB(A)		Average of two highest actual noise levels = 57.4 dB(A)	

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

EXTERIOR NOISE TEST DATA FORM
Stationary

Bus Number: 1107	Date: 12/13/11
Personnel: J.S., S.C., T.S. & B.L.	
Temperature (°F): 42	Humidity (%): 41
Wind Speed (mph): Calm	Wind Direction: Calm
Barometric Pressure (in.Hg): 30.40	

Verify that microphone height is 4 feet, wind speed is less than 12 mph and ambient temperature is between 30°F and 90°F: ■ checked by: S.C.

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

Exterior Ambient Noise Level dB(A): 34.5

Accessories and Air Conditioning ON

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	N/A	43.9	41.9
High Idle	N/A	N/A	N/A
Wide Open Throttle	N/A	N/a	N/A

Accessories and Air Conditioning OFF

Throttle Position	Engine RPM	Curb (Right) Side dB(A)	Street (Left) Side db(A)
		Measured	Measured
Low Idle	N/A	43.1	42.6
High Idle	N/A	N/A	N/A
Wide Open Throttle	N/A	N/A	N/A

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

Comments: Test vehicle is electric.

7.2 EXTERIOR NOISE TESTS

TEST BUS UNDERGOING
EXTERIOR NOISE TEST